
ANNUAL REPORT FY2015
POWERED THROUGH
PARTNERSHIP
CASIS™
ISS
U.S. NATIONAL LABORATORY

TABLE OF CONTENTS

LETTER FROM THE PRESIDENT

ISS National Laboratory: *Powered Through Partnership.* As the International Space Station (ISS) closes in on the milestone of 15 years of continuous human presence in low Earth orbit, we pause to reflect on an incredible year of progress onboard the ISS U.S. National Laboratory. This year was a challenging one for our community, with three failed ISS resupply missions and the tragic loss of human life in the Virgin Galactic accident. These moments tested the character and conviction of new emerging space companies, implementation partners, ISS users, policy stakeholders, and NASA. However, what evolved demonstrated the tremendous focus and strength in this growing industry.

Gregory H. Johnson

In response to these challenges, new partnerships emerged, the user community continued to unite and prosper, and public excitement for space continued to reach new heights—from New Horizons to the One Year Mission and even the film The Martian. The ISS National Lab is proving to be fertile ground for R&D innovations for commercial companies, academic institutions, government agencies, and student research. In fiscal year 2015 (FY15), we celebrated many achievements:

- *Growing non-traditional user demand—the ISS National Lab reached full capacity for allocated crew time for research that was both scientifically and economically reviewed for Earth benefit.*
- *Conducting the first-ever mouse bone-density scans in orbit—improving the capability to study bone and muscle loss in rodent models (as an accelerated pathway to better treatments for osteoporosis and muscle atrophy on Earth).*
- *Mounting of the first commercial platform on the exterior of the ISS for commercial testing of research payloads, sensors, and electronic components in space—created and sponsored by the ISS National Lab commercial service provider NanoRacks, LLC.*
- *Carrying out projects yielding protein crystals large enough for neutron diffraction analysis, continuing to validate the promise of space-based crystal growth alongside increased commercial interest and opportunity. Many such crystals are currently difficult to grow in significant size or quality on Earth.*
- *Receiving significant outside investments in ISS National Lab programming, including an agreement from the National Science Foundation to commit $1.8 million toward an ISS National Lab sponsored program, a $550,000 grant from the Massachusetts Life Sciences Center for flight and education projects, and more than $250,000 from the Boeing Company to match a CASIS partnership with the Mass Challenge Accelerator program.*

While just four years into our journey managing the ISS National Lab, CASIS is excited to see many positive signals toward our long-term goals. By 2025, we envision sustainable user demand, with investments in ISS National Lab research and development exceeding $100 million on an annual basis. We are targeting a cumulative economic impact of more than $4 billion from ISS National Lab activities and are aiming to reach more than 2 million students annually through educational initiatives associated with ISS programs and partnerships. These are bold but achievable goals that will significantly impact the legacy of the ISS and help cultivate next-generation innovation platforms in low Earth orbit. We thank the entire ISS National Lab community for its ongoing engagement and support as the ISS continues to evolve as a unique platform for microgravity research, Earth observation, materials testing, and education initiatives. Since its inception, the ISS has been a global symbol of the power of human achievement and collaboration. Our progress onboard the ISS National Lab is rooted in this spirit—engagement in a one-of-a-kind laboratory truly powered through partnership.

Best,

Gregory H. Johnson
President and Executive Director, CASIS

ISS U.S. NATIONAL LABORATORY

NASA CASIS

POWERED THROUGH PARTNERSHIP

ABOUT CASIS AND THE ISS NATIONAL LAB

The ISS U.S. National Laboratory is an orbiting platform for research, technology development, and education that inspires innovation and opportunities for discovery that benefit life on Earth, pushing the frontiers of scientific knowledge. The Center for the Advancement of Science in Space (CASIS) has a mission to manage and provide access to this first and only National Laboratory in space, demonstrating to U.S. citizens and the world that space-based research is accessible, affordable, and capable of supporting R&D for far more than space exploration. It is the congressionally mandated mission of CASIS to maximize use of this unique laboratory as a means to accelerate knowledge and commercial development on Earth for the benefit of humankind. In concert with this mission,

the focus of the ISS National Lab is to foster innovative research, inspire students, and stimulate demand for a sustained commercial economy in low Earth orbit.

CASIS is committed to changing the culture of space-based R&D and enabling greater access to low Earth orbit, where investigators can access microgravity, the vantage point of the orbiting ISS, and the extreme environment of space. Through these unique features, the ISS continues to enable investigations that are not possible on Earth—accelerating the timeline to tangible Earth benefits from space-based discoveries. For the first time in history, the ISS National Lab allows utilization of this powerful platform by nontraditional users, enabling results that can be achieved faster and that are more robust than those of ground-based studies—and sometimes allowing discoveries that are truly inaccessible to terrestrial investigations. We at CASIS recognize the great responsibility we have to maximize use of this unique lab to benefit life on Earth, and in this report we share the details of our FY15 stewardship of ISS National Lab resources toward the specific mission objectives defined by our Cooperative Agreement with NASA:

1 **INCREASED UTILIZATION:** *"stimulate, develop, and manage the U.S. national uses of the ISS by other U.S. government agencies, academic institutions, and private firms," and*

2 **INCREASED AWARENESS:** *"develop tools and techniques to communicate the value of uses of the ISS National Laboratory and increase the return on the U.S. investment in the ISS."*

As the launch center for creative ideas, disruptive technologies, and educational opportunities to the ISS National Lab, CASIS places its mission above all else as we work to facilitate national objectives and improve the new user journey. Through this mission, CASIS hopes to maximize the value of the ISS to the nation by using the ISS as a venue for educational activities and by enabling impactful space-based research that aims to improve human health and develop commercial products and technologies to reinforce U.S. relevancy in the global high-tech marketplace.

Read on to explore how the ISS National Lab is linking a dynamic community of researchers, innovators, and educators who seek discoveries that will take us beyond the current thresholds of knowledge to create a more extraordinary future.

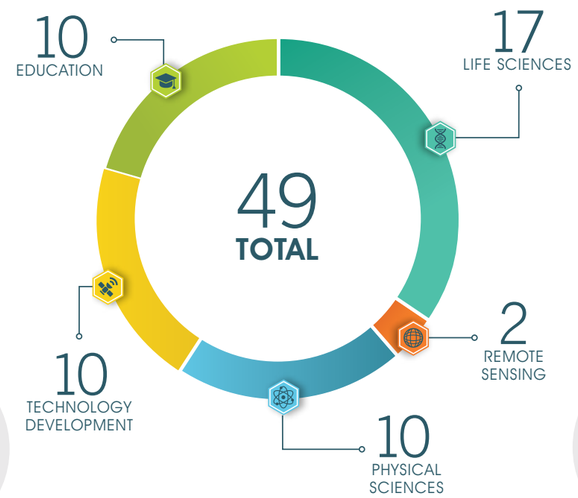
FY15 ANNUAL ACHIEVEMENTS

To convey organizational progress toward improved utilization of the ISS National Lab, CASIS tracks a number of strategic and operational metrics that align with our congressionally mandated goals. Below are selected highlights from these data that illustrate powerful and informative trends toward benchmarks of success—including expanded outreach to students, the public, and new users; expansion and diversification of the R&D portfolio; and project outcomes (publications and products). Read on to discover where we have been in FY15 and for indications of where we are heading in the future of space-based R&D.

MORE THAN
$4.1 million
CASIS FUNDING ATTRIBUTED TO PROJECTS

77
PROPOSALS RECEIVED

CASIS AWARDED PROJECTS
FY15



22
NEW-TO-SPACE CUSTOMERS

4
RETURNING CASIS CUSTOMERS

19%
CASIS CONTRIBUTION TO PROJECT COST
(see p.22)

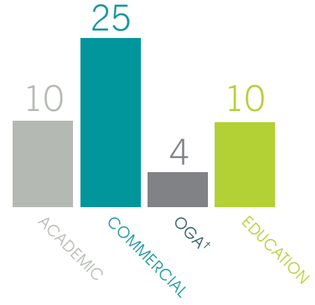
1
PRODUCT LAUNCHED
(see p.7)

8
PUBLICATIONS
(see p.9)

RESEARCH PUBLICATIONS (e.g., journal articles) are a critical means to disseminate findings from R&D initiatives. Typically peer reviewed, these publications often lend credibility, prestige, and merit to investigators, hypotheses, and even research platforms such as the ISS National Lab. Moreover, a strong publication base often precedes commercial investment in a particular sector.

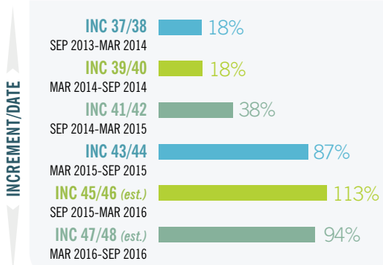
FY15 AWARDED PROJECTS BY CHANNEL*

FY15 AWARDED PROJECTS BY ORGANIZATION TYPE



* Solicitations include CASIS-issued research opportunities as well externally sponsored competitions. Unsolicited projects refer to proposals received outside of these formal opportunities. All proposals are reviewed via a competitive process.
† ISS National Lab research initiatives sponsored in collaboration with an OGA, or Other Government Agency.

CREW TIME USAGE



FOR THE FIRST TIME THIS YEAR, CASIS payloads were abundant enough to require all of the ISS National Lab allocated crew time (50% of the total U.S. allocation). While this validates CASIS strategy and execution plan to stimulate demand for use of the ISS National Lab, it also suggests that the allocated 50% of U.S. resources on the ISS may be insufficient to serve non-NASA "customer" demands.

98
FLIGHT PROJECTS MANIFESTED

41
FLIGHT PROJECTS DELIVERED

Represents complete ISS National Lab portfolio, including projects sponsored by NanoRacks

THE ISS NATIONAL LAB supports some projects that are not directly sponsored by CASIS—in particular, commercial payloads managed by the commercial service provider NanoRacks, LLC. These projects make up a large portion of the R&D sent to the ISS in FY15 (25 of the 41 payloads delivered). CASIS enables success of these projects by providing allocation of resources (upmass, crew time, etc.).

FY15 EDUCATION & OUTREACH METRICS

120,692 OVERALL REACH FOR EDUCATION

251,130 WEBSITE VISITORS

78,362 TWITTER FOLLOWERS

4,958 FACEBOOK LIKES

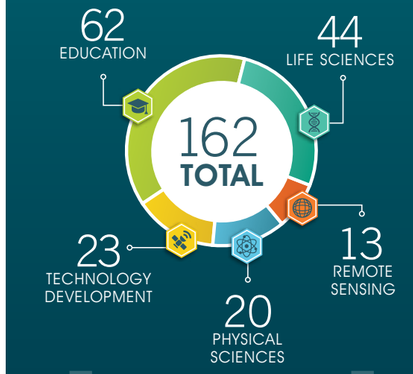
3,734 NEWS MENTIONS

26 MEDIA EVENTS

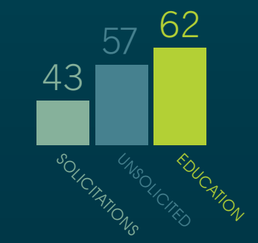
22 NEWS RELEASES

UNDER OUR COOPERATIVE AGREEMENT WITH NASA, CASIS is directed to "diversify" the R&D portfolio of the ISS National Lab. This includes increasing commercial use of the lab as well as balancing the portfolio to include projects from varied disciplines. Over the past year, CASIS has increased both commercial involvement in the portfolio as well as diversity among the disciplines of awarded projects.

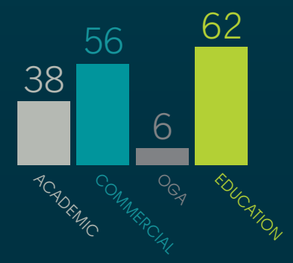
TOTAL PORTFOLIO
TO DATE (FY11-FY15)



BY CHANNEL



BY ORGANIZATION TYPE

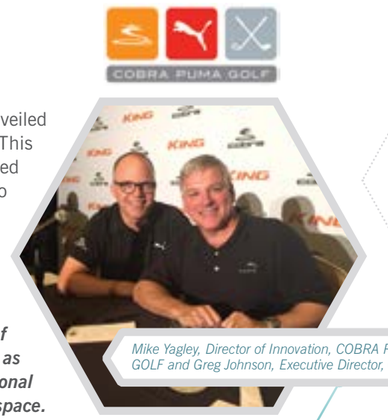


COMMERCIAL INNOVATION

Through CASIS, private companies now have an unprecedented opportunity to use the ISS National Lab as a research platform and test bed for commercial R&D. These new users include pharmaceutical juggernauts, sporting goods manufacturers, early stage entrepreneurial businesses, and many others across a variety of sectors. While the applications derived from microgravity research differ among this new user base, the growing interest in space research from the commercial realm, via an improved access model, conveys a strong singular message: ***commercial innovation is taking place in space.***

Non-Traditional Users

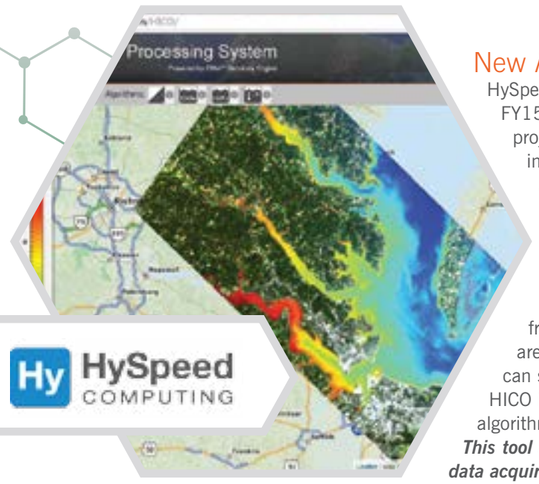
In August 2015, COBRA PUMA GOLF unveiled its latest product, the King LTD Driver. This dynamic piece of golf equipment was developed with space-inspired enhancements related to COBRA PUMA's experiments on the ISS in FY14. Through the product launch, CASIS positioned the ISS National Lab as a reliable research platform for commercial R&D. ***The partnership between CASIS and COBRA PUMA GOLF further showcases the benefits of ISS research for consumer goods and products as well as the diversity of the new and non-traditional users that are seeking to conduct research in space.***



Mike Yagley, Director of Innovation, COBRA PUMA GOLF and Greg Johnson, Executive Director, CASIS

COBRA PUMA GOLF's King LTD Driver

> *From our own particular perspective, the ISS National Lab provides a unique opportunity for innovative Earth observation missions, most notably serving as a robust, highly functional platform for remote sensing technology demonstration and data fusion.*
> —Dr. James Goodman, HySpeed Computing



New Applications and Products

HySpeed Computing developed and launched a brand new commercial product in FY15 that provides remote sensing data analysis in the cloud. The company's project, awarded in response to a CASIS-issued solicitation focused on Earth imaging, produced a web tool that is now available online: *The Hyperspectral Imager for the Coastal Ocean (HICO) Image Processing System (IPS).* HICO, though now retired from use on the ISS, was the first space-borne imaging spectrometer designed to study the coastal ocean. HICO IPS is a computing application for image analysis and data visualization of the more than 10,000 images of Earth that HICO collected during its five years of operations (September 2009–September 2014). HICO IPS differs from other online map services because it is an application-server, so results are dynamically generated on-demand per the user's request. The system can support various remote sensing instruments and applications in addition to HICO images and data, providing an adaptable framework for implementing new algorithms and making new applications available to the global user community. ***This tool advances the CASIS mission by enabling a broader audience to translate data acquired in space into applications to benefit life on Earth.***

AWARDED FY15 ISS NATIONAL LAB COMMERCIAL USERS

1DropDiagnostics · A2M · Astrileux · BUSINESSINTEGRA · CAMMED · Controlled Dynamics Inc. · D-ORBIT · DSI · ECLIPSE · JUXTOPIA · Lilly · NANOBIOSYM · nemak · NOVOPYXIS · ONCOLINX · RMD A Dynal Company · Space Tango · SQZBIOTECH · TATE & LYLE · VISIDYNE · Vision · FLOW TECHNOLOGY

NanoRacks External Platform

THROUGH A PARTNERSHIP WITH NANORACKS, the ISS National Lab's research capabilities were expanded with the addition of the NanoRacks External Platform (NREP), which arrived to the ISS in August 2015. This is the first external commercial research platform installed on the ISS. The NREP will allow scientists to test sensors, components, and other investigations in the extreme environment of space. Several ISS National Lab projects will be among the first to use the NREP, when it comes online in spring 2016.

Cutting Edge R&D

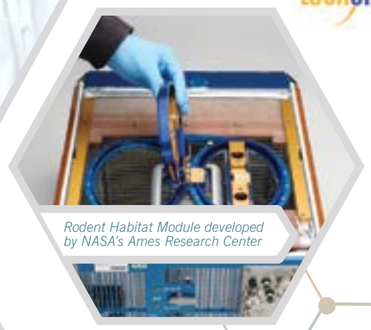
The ISS National Lab achieved robust successes in FY15 in the area of rodent research, with two CASIS-sponsored projects (both from the Novartis Institute for Biomedical Research) making use of brand-new rodent research hardware onboard the ISS. The first project was the Rodent Research-1 mission, flown in January 2015, which validated the Rodent Habitat Module. The second was the Rodent Research-2 mission, flown in April 2015, which used the commercially built bone density scanner (Bone-D) onboard the ISS to complete successful scans on mice in space. These successful missions validated crucial research instruments in orbit that will green-light future ISS research investigations. The expanded capabilities of the ISS National Lab will foster increased research utilization, and the use of commercial off-the-shelf equipment saves development costs traditionally associated with space-bound specialized equipment. ***The successful Bone-D operation is a landmark achievement for microgravity research and paves the way for an exciting new era of disease modeling research in space.***

NOVARTIS

Sam Cadena, Novartis Program Manager for Rodent Research missions

The Bone Densitometer developed by Techshot Inc.

techshot

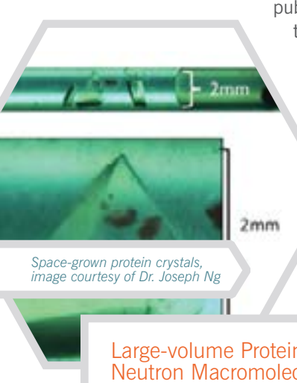


Rodent Habitat Module developed by NASA's Ames Research Center

HIGHLIGHTS FROM FY15 PUBLISHED RESULTS

In its four short years of operations, CASIS has already enabled dozens of projects to fly to the ISS and return for postflight evaluation. It takes time to analyze the breadth and depth of data from complex experiments after their return to Earth, but some CASIS-sponsored principal investigators are already beginning to announce exciting results. In addition, preflight experiments are also producing findings that promise further knowledge advancement from upcoming space-based inquiries. Last year, the ISS National Lab entered a new phase, as CASIS-sponsored payloads began to fly and return; this year, an equally critical phase has begun, as research results begin to emerge from preflight and postflight data.

In FY15, eight research papers resulting from CASIS-sponsored investigations were published, formally announcing some of the preflight and postflight findings. Peer-reviewed journal articles and other research publications are a critical means for the scientific community to disseminate research findings, and such publications often lend merit and prestige to initiatives—and to the ISS National Lab by association, bringing visibility and credibility to this powerful research platform. Below are details on the research publications released in FY15. R&D works in a stepwise fashion, so the landmark findings and incremental progress showcased in these publications illustrate continued traction toward the ultimate goals of health care advancement, technology innovation, and other achievements that will improve overall knowledge and quality of life for humankind.



Space-grown protein crystals, image courtesy of Dr. Joseph Ng

Collective Search by Ants in Microgravity

Principal Investigator: Stefanie Countryman
Institution: BioServe

- **RESULTED FROM:** An educational program, "Ants in Space" (originally sponsored by NASA and later subsidized by CASIS), that launched on Orb-1 in January 2014.
- **DESCRIPTION:** This project studied ant collective search behavior in microgravity. Algorithms describing this behavior are critical to understanding group foraging in social insects and other systems of collective behavior, including technology applications. This paper describes how ants in microgravity explored search areas less thoroughly and took paths that are more convoluted. This project continues as a ground-based education program, leveraging results from the flight project.
- **POTENTIAL IMPACT:** Refined collective behavior algorithms (e.g., for programming swarms of robots to optimize search-and-rescue capabilities).
- **CITATION:** Countryman SM, Stumpe MC, Crow SP, Adler FR, Greene MJ, Vonshak M and Gordon DM (2015) Front. Ecol. Evol. 3:25.

Large-volume Protein Crystal Growth for Neutron Macromolecular Crystallography

Principal Investigator: Dr. Joseph Ng
Institution: iExpressGenes

- **RESULTED FROM:** A project awarded in response to a CASIS solicitation promoting protein crystal growth.
- **DESCRIPTION:** Understanding a protein's function in the body and its susceptibility to various drug treatments requires determining the protein's structure, which in some cases requires very large protein crystals for analysis. This review paper describes methods of growing very large crystals and presents images of space-grown crystals as an example of how a lack of buoyancy-driven convection onboard the ISS allows improved crystal formation and growth.
- **POTENTIAL IMPACT:** Better drug design for new and more effective drugs with fewer side effects.
- **CITATION:** Ng JD, Baird JK, Coates L, Garcia-Ruiz JM, Hodge TA and Huang S (2015) Acta Crystallogr. F Struct. Biol. Commun. 71(4):358.

Hourly Turbidity Monitoring Using Geostationary Ocean Color Imager Florescence Bands

Principal Investigator: Dr. Ruhul Amin
Institution: Naval Research Laboratory

- **RESULTED FROM:** An award in response to a CASIS solicitation promoting the use of imagery from the ISS-based sensor Hyperspectral Imager of the Coastal Ocean (HICO).
- **DESCRIPTION:** This project aimed to detect algal blooms from space-based imaging. When HICO became dysfunctional during the study period, the authors used other space-borne sensors, such as the Geostationary Ocean Color Imager, to continue the research. The authors were able to successfully distinguish algal bloomed regions from other bloom-like features and monitor their movement, linking the movement patterns with tidal forces.
- **POTENTIAL IMPACT:** Early warnings for harmful algal bloom occurrences (e.g., red tide), affecting human health and the multibillion-dollar fishing and tourism industries.
- **CITATION:** Amin R, & Shulman I (2015) J. Appl. Remote Sens. 9(1):096024.

Anti-PolyQ Antibodies Recognize a Short PolyQ Stretch in Both Normal and Mutant Huntingtin Exon 1

Principal Investigator: Dr. Pamela Bjorkman
Institution: California Institute of Technology

- **RESULTED FROM:** An award in response to a CASIS solicitation promoting protein crystal growth on the ISS.
- **DESCRIPTION:** This paper discusses results from ground-based experiments (in preparation for a flight experiment) in which the authors examined the structure of a polyglutamine (polyQ) repeat in the huntingtin protein, the expansion of which is the cause of Huntington's disease. The authors used protein-binding studies to demonstrate that the disease-causing expanded repeat is likely not a specific pathologic conformation and is thus not a target for structure-based drug design.
- **POTENTIAL IMPACT:** Novel treatment approaches for Huntington's disease, an inherited neurodegenerative disease for which there is no cure.
- **CITATION:** Owens G, New D, West A, and Bjorkman P (2015) J. Mol. Biol. 427(15):2507.

Simulated Microgravity Exerts an Age-Dependent Effect on the Differentiation of Cardiovascular Progenitors Isolated from the Human Heart

Principal Investigator: Dr. Mary Kearns-Jonker
Institution: Loma Linda University

- **RESULTED FROM:** An award in response to a CASIS solicitation promoting stem cell research.
- **DESCRIPTION:** This paper describes the differential impact of simulated microgravity on isl-1+ cardiovascular progenitor cells isolated from human neonates and adults, showing that stem cell responses to microgravity may be influenced by age. The authors demonstrate that simulated microgravity can be used to manipulate the process whereby neonatal cardiovascular progenitor cells activate a conserved regenerative microRNA program. Future studies on the ISS will determine whether a similar effect occurs in the space environment.
- **POTENTIAL IMPACT:** New therapies for heart disease, which is the number-one cause of death in the U.S.
- **CITATION:** Fuentes TI, Appleby N, Raya M, Bailey L, Hasaniya N, Stodieck L, and Kearns-Jonker M (2015) PLoS ONE 10(7).

Note: This is the second publication associated with the suite of projects resulting from the CASIS stem cell research solicitation. Dr. Chunhui Xu from Emory University published the first in FY14: Nguyen DC, et al (2014) Stem Cell Reports 3(2): 260-268.

Luminescent Viability Assays in Magnetically Bioprinted 3-D Cultures

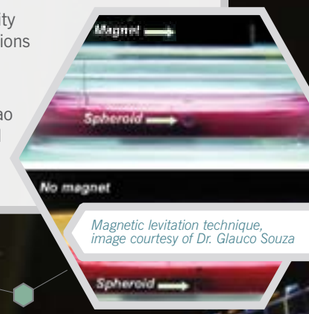
Principal Investigator: Dr. Glauco Souza
Institution: Nano3D Biosciences, Inc.

- **RESULTED FROM:** A competitive award to an entity engaged through strategic commercial outreach programs.
- **DESCRIPTION:** This article discusses a magnetic 3-D bioprinting method for rapidly and reproducibly printing cancer and liver cells into 3-D spheroids in high-throughput format, developed by Nano3D Biosciences, Inc. The article discusses how these spheroids can be successfully used with existing cell viability commercial products.
- **POTENTIAL IMPACT:** Acceleration of regenerative medicine, such as heart tissue replacement and organ transplantation.
- **CITATION:** Tseng H, Gage JA, Desai PK, Haisler WL, Shah JV, Li W, and Souza GR (2015) Promega Corporate, online.

A Spheroid Toxicity Assay Using Magnetic 3-D Bioprinting and Real-time Mobile Device-Based Imaging

Principal Investigator: Dr. Glauco Souza
Institution: Nano3D Biosciences, Inc.

- **RESULTED FROM:** A competitive award to an entity engaged through strategic commercial outreach programs.
- **DESCRIPTION:** This paper describes how Nano3D Biosciences, Inc. has devised a novel assay (or test) for using 3-D cell aggregates (also known as spheroids) created with magnetic 3-D bioprinting for toxicity screening. The assay can detect the toxic effects of drugs with both accuracy and high-throughput to meet the needs of researchers in drug discovery and development for fast and robust models by simply using real-time imaging with a mobile device. This methodology can be readily implemented to support, facilitate, and enable biomedical research performed in space for terrestrial benefit.
- **POTENTIAL IMPACT:** Improved toxicity testing of drugs, leading to medications with fewer side effects.
- **CITATION:** Tseng H, Gage JA, Shen T, Haisler WL, Neeley SK, Shiao S, Chen J, Liao A, Hebel C, Raphael RM, Becker JL, and Souza GR (2015) Sci. Rep. 5:13987.



Magnetic levitation technique, image courtesy of Dr. Glauco Souza

> *"Nano3D's technology is a good example of progress enabled by CASIS. If it weren't for CASIS, Nano3D's technology would not have been adapted to be used as a general tool for biological experimentation on the ISS, which should expand the possibilities of performing biological research in space."*
> —Dr. Glauco Souza, Nano3D Biosciences, Inc.

Spaceflight Alters Expression of MicroRNA During T-cell Activation,

Principal Investigator: Dr. Millie Hughes-Fulford
Institution: The Veterans Health Research Institute

- **RESULTED FROM:** An ISS National Lab project originally funded by the NASA NIH-BioMed program and later subsidized by CASIS.
- **DESCRIPTION:** This study found that key immune genes targeted by the microRNA miR-21 were differentially regulated in spaceflight, specifically showing that gravity itself is responsible for part of the dysregulation of the immune system during spaceflight. The authors also discovered a new way that miR-21 regulates the human immune system. This previously unknown mechanism was termed "self-limiting induction" and could potentially play a role in many biological processes.
- **POTENTIAL IMPACT:** New treatments for wound healing and cancer, major health issues affecting our aging population.
- **CITATION:** Hughes-Fulford M, Chang T, Martinez E, and Li C (2015) FASEB J. 15:277392.

OUTREACH & IMPACT

Central to the CASIS mission is an effective strategy to communicate the R&D benefits and accessibility of the ISS National Lab. Such outreach efforts in FY15 have bolstered awareness and perception of the ISS among the academic research community, industry, the education community, and the public. Through conferences, industry events, social and traditional media, and strategic positioning, the ISS National Lab has achieved an elevated profile as a pioneering research platform that can support myriad investigations and educational initiatives, showcasing our orbiting outpost as an important launch point for the burgeoning market that is revolutionizing and commercializing low Earth orbit.

REPRESENTATIVES FROM CASIS, NASA, Boeing, Orbital ATK, and other ISS National Lab partners (including Merck) participated in the New York Stock Exchange closing bell ceremony in June 2015.

Impacting Industry

- CASIS participated in 27 industry events in FY15, showcasing the R&D benefits of the ISS National Lab to many prospective researchers.
- The ISS National Lab had significant visibility at the 2015 **BIO International Convention**, attended by 16,000 representatives from leading biotech companies. At this event, CASIS held brainstorming sessions with 42 companies and organized a live downlink from the ISS.
- The ISS National Lab maximized its presence at the **American Association for the Advancement of Science (AAAS) 2015** Annual Meeting, the world's largest general science convention. Representatives from NASA's Ames Research Center, Made in Space, and Techshot, Inc. joined CASIS to display hardware, lend technical expertise, and support key messaging regarding ISS National Lab opportunities.
- **Destination Station**, a joint effort between NASA and CASIS that features a traveling exhibit, hosted five events across the country, during which CASIS met with companies such as BASF, Merck, Unilever, and General Mills—reaching thousands of employees.
- The ISS National Lab participated in various speaking opportunities, including an **American Association of Pharmaceutical Scientists** Webinar (organized by CASIS and Dr. Franklin Spriggs), reaching industry personnel in the pharmaceutical, biotechnological, and public health sciences.

SPOT LIGHT

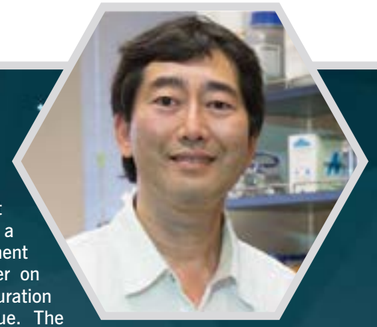
Dr. Allessandro Grattoni *Investigator Perspectives*

"I am the chairman of the Department of Nanomedicine at the Houston Methodist Research Institute (HMRI) in Houston, Texas. I started working with CASIS in 2013 on a microgravity investigation on the diffusive transport of particles under confinement. CASIS helped me to get my project off the ground and provided me with the funding and resources to perform my investigation in the unique environment onboard the ISS. Since this first experience, I have worked closely with CASIS on other research studies that leverage the ISS U.S. National Laboratory for science that could translate into biomedical applications on Earth. CASIS has been an incredibly valuable partner in helping me reach my scientific goals. My team and I received generous help from CASIS in preparing our proposal for consideration for funding and in coordinating our efforts with an implementation partner for successful execution of our project. Additionally, CASIS connected us with experts and scientists with ample background in life sciences research in microgravity, who helped us expedite, optimize, troubleshoot, and successfully execute our experiment. I was very pleased to learn that CASIS will re-fly our microfluidics experiment that was lost with the SpaceX-7 rocket. Thanks to support from CASIS, we have established a Center for Space Nanomedicine at HMRI, which is fully dedicated to nanotechnologies developed in space for medical applications on Earth and involves multiple flight experiments over the next five years. Finally, I acknowledge the great contribution that CASIS has provided in advertising my research efforts in the scientific community and beyond."

–DR. ALLESSANDRO GRATTONI, HOUSTON METHODIST RESEARCH INSTITUTE
(Project: Decoupling Diffusive Transport Phenomena in Microgravity)

SPOT LIGHT

Dr. Joseph Ng *Investigator Perspectives*



"CASIS was instrumental to the success of our microgravity protein crystal growth investigation onboard the ISS. We utilized microgravity to grow large-volume protein crystals, using the counter-diffusion equilibrium technique, that are suitable for both X-ray and neutron crystallography. Our protein of interest is a potential antibiotic drug target linked to several human pathogens. Our experiment launched on SpaceX-3, with one sample set returning on SpaceX-3 and another on SpaceX-4. The experiment lasted six months, which is currently the longest duration for any protein crystal growth experiment using the counter-diffusion technique. The experiment yielded the largest protein crystals of this type to date, with both sample sets containing crystals with volumes greater than 6 mm^3. The crystals were used to collect very-high-resolution X-ray and neutron diffraction data sets to be used for protein structure determination. Consequently, we now have an unprecedented view of the atomic structure for this protein drug target, which allows us to proceed with detailed drug modeling. Our accomplishments would not have been possible without the funding and support from CASIS to perform the extensive ground work, launch preparations, spaceflight management, and postflight analyses."

–DR. JOSEPH NG, IXPRESSGENES *(Project: PCG – IPPase Crystal Growth in Microgravity)*

Stimulating Public Awareness

- Many ISS National Lab projects have been highlighted in **trade magazines and popular media**. For example, a *Scientific American* blog entry featured the education-focused Student Spaceflight Experiments Program (described on page 15), a *Popular Science* premium feature article highlighted the Intuitive Machines terrestrial return vehicle, and multiple media outlets (including the *Boston Herald* and *Science Daily*) featured a materials science project studying synthetic muscle (from RasLabs, LLC).
- **Mass media coverage** for the ISS R&D Conference (discussed on page 13) spanned some of the most recognizable publications and outlets in the world *(Bloomberg, MSN, Yahoo News, Huffington Post, ABC News, CBS News, NBC News, Mashable, New York Post, Chicago Tribune, Reuters, The Verge, Boston Globe,* and *Washington Times)*.

ADVANCING RESEARCH KNOWLEDGE 3 (ARK3) encompasses all payloads launched to the ISS National Lab during 2015. Celebrity and space advocate Seth Green designed the ARK3 patch, and a CASIS video about the patch garnered substantial attention through CASIS and NASA social media (with more than 200,000 views and 60,000 likes in the first month). Seth Green was also nationally featured on the talk show "The View," talking about the patch and video.

Education Outreach

- CASIS representatives participated in the **Destination Imagination** Global Finals event (May 2015), which hosted more than 19,000 students competing in a multidisciplinary challenge that reinforces critical thinking, team building, and project management.
- Along with myriad CASIS-run educational programs, the ISS National Lab also supported several programs in collaboration with other entities in FY15; for example, the Boeing **Genes in Space** national competition, which challenged educators and students in grades 7-12 to design experiments that will solve real-life space exploration problems through DNA analysis. This year, 700 students participated.
- **AAAS Family Science Days** is a two-day STEM (science, technology, engineering, and mathematics) expo that is held concurrently with the AAAS Annual Meeting. There was great ISS National Lab visibility at this event, as CASIS hosted an interactive exhibit for more than 3,000 students, educators, and parents in addition to sponsoring the Meet-An-Astronaut presentation, featuring retired NASA Astronaut Dan Bursch.
- **The National Science Teacher's Association** annual conference provided a great opportunity to educate the primary and secondary education community about ISS National Lab educational resources, with more than 12,000 education professionals in attendance.

Destination Imagination Global Finals Event

GAINING A NEW PERSPECTIVE

2015 ISS R&D CONFERENCE

The 4th annual ISS Research and Development Conference, cosponsored by CASIS, NASA, and the American Astronautical Society, was held in Boston, MA, and served as a unifying platform for the space research community. The event attracted a record number of attendees, more than doubling the previous year's attendance. Commercial companies engaging in space research through the ISS National Lab, including Eli Lilly and Merck, took the opportunity to showcase the research they are conducting on the ISS. Innovative companies, including Made In Space, NanoRacks, Nanobiosym, and Ras Labs, talked about the significance of the ISS National Lab as a research platform and the new advances to come.

Uniting the Community

- The event featured a wide range of speakers, including principal investigators, astronauts (active and retired), aerospace executives, NASA and CASIS officials, and a variety of participants from STEM education initiatives.
- An industry luminary conversation with Elon Musk (founder of SpaceX) was broadcast on Bloomberg.com and NASA TV and was viewed after the conference more than 180,000 times—a significant boost to ISS outreach efforts.
- Diverse attendance included representation from academia, industry, press, and international partners—showcasing the wide array of research conducted by the ISS community.
- The New User Workshop attracted more than 90 attendees, providing a catalyst for connecting new-to-space companies to established space veterans.
- More than 15 startup and early stage companies participated in 1:1 mentoring sessions with angel investors.
- Massachusetts Governor Charlie Baker announced the Galactic Grant Competition winners.

The 4th annual ISS R&D Conference boasted a record 706 attendees

Elevating STEM Education

- Student research teams from the National Design Challenge and the Student Spaceflight Experiments Program presented their research, experiment designs, and the valuable lessons learned from the Orb-3 anomaly.
- Boeing announced the winner of its Genes in Space Competition, who was chosen from more than 330 student entries.
- In collaboration with the Massachusetts Institute of Technology and the Boston Museum of Science, CASIS held an interactive learning experience, Space Station STEM Days, concurrently with the ISS R&D Conference.

ISSR&D CONFERENCE 2015

Massachusetts Governor Charlie Baker announces the winners of the Galactic Grant Competition

Zero Robotics booth in the exhibit hall at the ISS R&D Conference

Paul Reichert, a researcher from Merck, discusses his protein crystal growth research

NEW TOOL

ISS Virtual Tour

MISSION: *To take visitors on a breathtaking interactive tour of the ISS in extraordinary detail.*

FEATURES: Built in 6K resolution, the tour covers the entire habitable area of the ISS inside and out. After viewing the exterior of the ISS with the vast expanse of Earth floating elegantly beneath, visitors can learn about each module and go inside the station. As visitors "walk" through each module, they can explore "hotspots" that contain information about the hardware and facilities on the ISS and videos of astronauts talking about living and working in space. The tour also allows visitors to learn about current experiments onboard the station.

SPECIFICATIONS: The first iteration of the tour was built as a mobile 55-inch 4K UHD touch-screen display with stereo surround sound. The tour includes 15 scenes, more than 150 hotspots, upwards of 50 videos, and 250 images and other media.

AUDIENCE: The ISS virtual tour is perfect for a wide range of large-scale audiences—museums, visitor's centers, schools, trade shows, retail locations, and other public spaces. Anyone can experience the wonder and excitement of the ISS through this one-of-a-kind tour.

RELEASE DATE: The ISS virtual tour was launched in July 2015 at the ISS R&D Conference.

706 ATTENDANCE

4,500 LIVESTREAM VIEWERS

3.2 billion TOTAL MEDIA IMPRESSIONS

80.4 million SOCIAL MEDIA IMPRESSIONS

Elon Musk, keynote speaker

> *"We've been exhibiting at the ISS R&D Conference since its inception—it's the year's most important event for connecting with prospective commercial customers. Every year we've seen not just an increase in the number of attendees, but also an increase in optimism and energy among the diverse organizations represented. This year we noted a seismic shift in sentiment from "why should we conduct research onboard the ISS National Lab" to "how can we conduct our research in space," which is great, because Techshot is in the business of "how."* —Rich Boling, Techshot, Inc.

NEW TOOL

Researcher Portal

SPACESTATIONRESEARCH.com

MISSION: *To provide researchers with a one-stop shop for resources to discover the infinite possibilities of the new era of science in space for life on Earth.*

FEATURES: Through the portal, researchers can access all the tools, information, and resources they need to optimize project development, give their research a competitive edge, and take the first step in exploring the potential of space-based research. Researchers can learn about the benefits of microgravity and the space environment, and can explore a searchable collection of hardware, facilities, and other ISS capabilities. Researchers can use the portal to connect with CASIS and implementation partners to help get their research onboard the ISS.

SPECIFICATIONS: The portal contains a searchable database of current ISS National Lab projects and space-based research publications that researchers can browse. It also lists NASA resources, launch vehicles and the launch schedule, funding and flight opportunities, and CASIS-sponsored initiatives. In addition, the portal provides access to the ISS virtual tour—an interactive tool through which researchers can explore the ISS and its capabilities in extraordinary detail. The portal also features videos, blog posts, and stories on current projects.

AUDIENCE: Researchers from a broad range of fields and research settings can use the portal to accelerate their path to space-based research.

RELEASE DATE: The researcher portal was launched in July 2015 at the ISS R&D Conference.

This website is an emerging tool that continues to be populated with updated facilities information and publication data.

SAVE THE DATE » 2016 ISS R&D Conference: *July 12-14, San Diego • www.issconference.org*

INSPIRING TOMORROW'S EXPLORERS

Students watch a science demo at Zero Robotics' Field Day event

The ISS National Lab inspires the next generation of explorers and innovators through initiatives focused on science, technology, engineering, and mathematics (STEM) education, and CASIS continues to mature its wide-ranging outreach strategies to engage new communities in these activities. In FY15, CASIS focused on national partnership development and other collaborative ways to maximize the inspiration and research capabilities of the ISS for students and educators across the country. Debut programs including the Space Station STEM Challenge and Genes In Space (sponsored by the Massachusetts Life Sciences Center and Boeing, respectively) have introduced new communities to the ISS—and alongside traditional outreach approaches, these programs have produced a landmark year for student participation.

PROGRAMS

CASIS National Design Challenge

CASIS developed the National Design Challenge, a STEM education campaign that affords student teams the opportunity to design and implement an authentic research experiment on the ISS. Data from these experiments are downlinked to the ground for the students to analyze and compare with their ground-based data. CASIS and its industry partners assist the teams in experiment and engineering design and payload integration by providing resources, technical training, and support. In FY15, CASIS awarded five National Design Challenge flight projects (see page 25).

reach: 150 STUDENTS & EDUCATORS

Space Station STEM Challenge

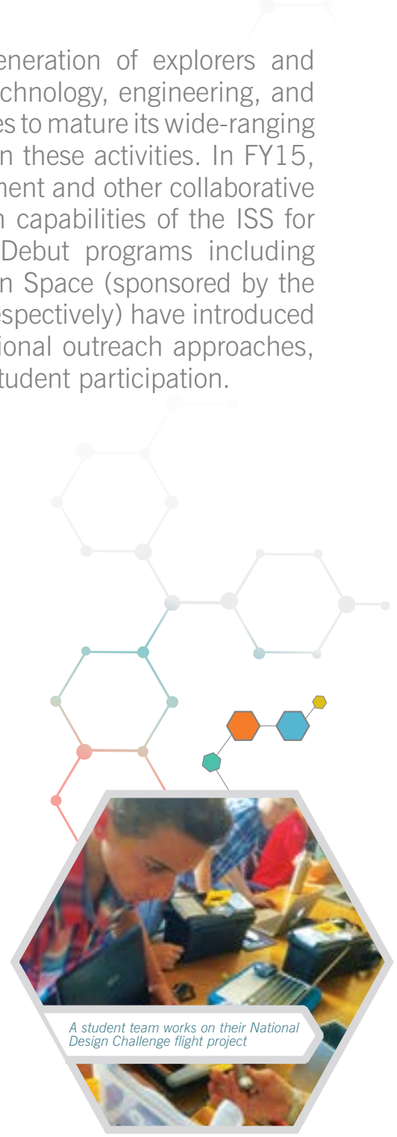
CASIS and the Massachusetts Life Sciences Center partnered to create an exciting research competition focused on raising awareness of the ISS and space research through authentic experiment design. Two Massachusetts schools (a flight team and ground control team) were selected to participate in this exciting challenge.

reach: 800 STUDENTS

CASIS Academy Live

An interactive STEM program, CASIS Academy Live educates students about the importance of research on the ISS and brings greater awareness to STEM careers. CASIS arranges for researchers, NASA astronauts, and STEM advocates to interact with participating students. Students also engage in hands-on activities that help shed light on some of the research that CASIS is facilitating on the ISS National Lab. Through a partnership with NASA's Digital Learning Network, CASIS Academy Live reaches classrooms across the country.

reach: 847 STUDENTS



A student team works on their National Design Challenge flight project

Zero Robotics

CASIS supports the Zero Robotics Competition, a robotics programming competition for middle school and high school students that was developed at the Massachusetts Institute of Technology. Students program robots known as Synchronized Position Hold Engage and Reorient Experimental Satellites (SPHERES) which are onboard the ISS. The high school program is held each fall and open to teams from the U.S. and member states of the European Space Agency. The middle school program is held each summer and open to U.S. teams and it is held during the summer. The finals tournaments are hosted onboard the ISS and broadcast live to students across the country.

reach: 3,999 STUDENTS & EDUCATORS

Story Time From Space

CASIS supports Story Time From Space, a project that combines STEM literacy and science. The program includes videos of astronauts in the cupola of the ISS, reading selected stories and conducting simple physics demonstrations that complement the STEM concepts in the books. Videos and data collected during the demonstrations are downlinked to the ground and posted in an online library with accompanying educational materials.

reach: 16,315 STUDENTS, EDUCATORS, & GENERAL PUBLIC + 25,000 WEBSITE VISITORS

Student Spaceflight Experiments Program

CASIS is a national sponsor of the Student Spaceflight Experiments Program, a project-based STEM program that was created by the National Center for Earth and Space Science Education to inspire and engage the next generation of scientists and engineers. Student communities engage in a proposal writing and experiment design process that culminates in their experiments being sent to the ISS.

reach: 12,040 STUDENTS

Ants In Space

CASIS is a sponsor of the BioServe Ants in Space program. Ants in Space offers students the opportunity to participate in an authentic science experiment that studies foraging ant behavior in the microgravity environment on the ISS. Students build their own ant habitats and compare their experiment results with those from the spaceflight experiment. There is a free standards-based curriculum guide provided for educators.

reach: 12,207 PARTICIPANTS

CASIS Ambassadors

The CASIS Ambassadors Program is comprised of exemplary professional educators and after-school professionals that are inspired to use ISS-related resources and content to enhance learning in the classroom and in after-school settings. CASIS ambassadors support CASIS outreach activities and serve as education subject matter experts for content development.

reach: 250 PARTICIPANTS

Space Station Academy

Space Station Academy is a comprehensive online simulation that takes participants on a mission to the ISS. The simulation includes astronaut training, a launch experience, and the details of living and working in space, including science research.

reach: 19,909 PARTICIPANTS

Amateur Radio on the International Space Station (ARISS)

CASIS is the ISS National Lab sponsor for ARISS, an educational outreach program sponsored by NASA. Students in the program are given the opportunity to speak with the ISS on-orbit crew using an amateur radio ground station at the school, set up by the students as part of an activity in which they study radio technology and wireless communication.

reach: 9,240 PARTICIPANTS

A student explores the ISS Virtual Tour at KSC's Community Day

Students participate in a Zero Robotics science demo

overall reach: 120,692* STUDENTS, EDUCATORS, & OTHER PARTICIPANTS

* Includes reach from programs, projects, conferences, and events.

ADDITIONAL EDUCATION OUTREACH

- Genes in Space: 700 STUDENTS
- Meet-An-Astronaut Series: 1,276 PARTICIPANTS
- Classroom Visits: 939 STUDENTS
- National Geographic Learning "Exploring Science" Project: 38,223 STUDENTS

EXPANDING THE CASIS NETWORK

Promoting awareness and utilization of the ISS National Lab is a multifaceted and vast effort, and it requires the power of partnership and collaboration to reach new audiences and new heights. Every conference attended, project awarded, and partnership formed helps expand the ISS National Lab network deeper into the scientific community and more expansively throughout the country. In FY15, CASIS expanded the reach of the ISS National Lab in many parallel ways, gaining traction in new areas and sectors while solidifying our reputation and relationships in established regional "ecosystems." Here is a snapshot of our activities in FY15—which approximately tripled the size of the ISS National Lab community engaged by CASIS.

> *"CASIS has made extraordinary progress in the variety of experiments being conducted on the ISS National Lab that will benefit humanity—both in space, as we continue to reach into the cosmos, and here on Earth, from fundamental scientific understanding to practical applications in extremely challenging environments."*
> —Dr. Lenore Rasmussen, Ras Labs

SPOT LIGHT

STEM Summit

The CASIS workshop "Leveraging the ISS for STEM Education" held in Cape Canaveral in January 2015 assembled 34 experts in the fields of STEM education and outreach. Workshop participants provided recommendations in four core areas essential to the success of CASIS education outreach—programs, funding, marketing, and measures of success.

Key recommendations were for CASIS to align its education programs with large national organizations that have well-established distribution channels, to partner with organizations that can leverage unique CASIS education content, and to secure outside funding to support CASIS education programs. These recommendations validated many current CASIS education outreach strategies. The workshop also helped CASIS develop new partnerships with prominent organizations.

The following are key FY15 CASIS STEM education partnerships that exemplify implementation of workshop recommendations.

BOY SCOUTS OF AMERICA AND EXPLORING SCOUTS

- CASIS formed a partnership with the Chicago-area Boy Scouts of America (BSA) and Exploring Scouts programs. CASIS and the BSA Pathways to Adventure Council launched a Space Station National Design Challenge student research competition in the Chicago area in spring 2015. Teams of 10 to 20 young men and women designed experiments to compete for the opportunity to fly their experiment on the ISS. *(Awarded projects listed on page 25.)*

MASSACHUSETTS LIFE SCIENCES CENTER

- CASIS expanded a partnership with the Massachusetts Life Sciences Center (MLSC), an investment agency that supports life sciences innovation, research, development, and commercialization. In spring 2015, CASIS and MLSC launched a grant competition for Massachusetts middle school students modeled on the CASIS National Design Challenge. MLSC contributed a $50,000 grant for the competition, in which students competed for the opportunity to fly their life sciences experiment on the ISS. *(Awarded projects listed on page 25.)*

CHALLENGER LEARNING CENTER AT FRAMINGHAM STATE UNIVERSITY

- CASIS also formed a partnership with the Challenger Learning Center at Framingham State University in Massachusetts. Challenger Center is an international organization dedicated to inspiring students through dynamic STEM education experiences, with a network of centers in four countries and 27 states. CASIS supplied content for the Framingham Challenger Learning Center's "Earth Odyssey" interactive simulation aimed at middle school and high school students.

NATIONAL GEOGRAPHIC LEARNING/CENGAGE LEARNING

- CASIS matured its partnership with National Geographic Learning (NGL)/Cengage Learning and supplied content for NGL's "Exploring Science" curriculum series. Exploring Science is an interactive series for grades K through 5 that introduces students to real-world scientific research. CASIS contributed content for the online curriculum supplement.

Zero Robotics Middle School Finals event, hosted by CASIS

EXPANDING THE CASIS NETWORK

LEGEND

FY15 Selected/Awarded Projects

- EDUCATION
- PHYSICAL SCIENCES
- TECHNOLOGY DEVELOPMENT
- LIFE SCIENCES
- REMOTE SENSING

- NEW PARTNERSHIPS IN FY15
- FY15 CONFERENCES & EVENTS

CASIS PRESIDENT AND EXECUTIVE DIRECTOR GREG JOHNSON participated in a live downlink event with Astronaut Scott Kelly, who is currently living onboard the ISS, during a keynote presentation at the 2015 BIO International Convention. This high-profile event was indicative of the increased visibility of the ISS National Lab among the research community due to robust outreach efforts in FY15.

What are Ecosystems?

To promote interest in space-based research, CASIS maintains a variety of user engagement strategies. In one such strategy, CASIS has positioned itself over the past three years within established geographical hubs of R&D innovation—known as ecosystems. Integration within an existing infrastructure has enabled CASIS to jumpstart interest in space-based R&D among new users and to engage stakeholders to fill key roles within a supply-and-demand marketplace for the ISS National Lab. Over the past two years, increased traction within these ecosystems has boosted access to leading university programs, funding sources, and clusters of knowledge-based businesses, validating the ecosystem engagement strategy. Notable successes include myriad flight projects resulting from participation in ecosystem-based business accelerator competitions as well as multiple new partnerships and collaborations.

SEATTLE, WA
- Spacefest
- Industrial Research Institute Annual Meeting

CALIFORNIA ECOSYSTEM
- Lux Capital
- American Association for the Advancement of Science (AAAS) Annual Meeting
- Destination Station
- CASIS Academy Live
- Palo Alto Innovation Tour
- WorldFuture 2015
- Space 2.0

LOGAN, UT
- AIAA Small Satellite Conference

COLORADO ECOSYSTEM
- Lockheed Martin New Ventures Fund
- Colorado Springs Angel Network
- Industrial Research Conference
- National Design Challenge - Denver Critical Design Review Workshop
- 31st Space Symposium

FLAGSTAFF, AZ
- Flagstaff Science Alliance

ALBUQUERQUE, NM
- New Mexico Angels Network

SoCAL ECOSYSTEM
- Space Angels Network
- Clinical Research Workshop (U.S. Navy Marine Mammal Program and National Marine Mammal Foundation)
- American Society for Gravitational and Space Research (ASGSR)
- Industrial Research Institute Spring Multi-Networks Meeting
- Biomarker Summit
- AIAA Space 2015

SCOTTSDALE, AZ
- CoDev 2015

LAS CRUCES, NM
- New Mexico Space Grant Consortium
- New Mexico State University/ Arrowhead Center
- International Symposium for Personal and Commercial Spaceflight (ISPCS)
- New Mexico Space Grant Consortium
- CASIS Education Presentation

EL PASO, TX
- Redsky

SAN ANTONIO, TX
- World Stem Cell Summit

MINNEAPOLIS, MN
- Destination Station

CHICAGO, IL
- Boy Scouts of America, Chicago Area Council
- National Science Teachers Association (NSTA) Annual Conference

DEARBORN, MI
- Industrial Research Institute Fall Networks Meeting

CLEVELAND, OH
- NASA FluidsLab and CombustionsLab Briefings

PHILADELPHIA, PA
- Destination Station
- BIO International

TARRYTOWN, NY
- Destination Station

KENILWORTH, NJ
- Destination Station

NEW YORK, NY
- Clinton Global Initiative 2015 Annual Meeting
- Destination Station

BOSTON ECOSYSTEM
- Mass Challenge Awards Ceremony
- Galactic Grant Challenge Press Conference
- MassBio Annual Meeting
- ISS R&D Conference
- Scaling STEM

KNOXVILLE, TN
- Destination Imagination Global Finals

HUNTSVILLE, AL
- Von Braun Symposium

D.C. ECOSYSTEM
- NextGen Angels
- InQtel
- LEO Commercialization Workshop
- Final NASA Economic Development of LEO Study Workshop

HOUSTON ECOSYSTEM
- Houston Angel Network
- Texas Halo Fund
- Dreamit Health
- National Design Challenge - Houston School Assemblies
- Pumps & Pipes
- Space-4-Houston
- 2015 Human Researcher Program Investigators' Workshop
- Air Quality Technologies ICC Event
- Deep Space, Deep Ocean Conference
- Rice Business Plan Competition

SPACE COAST ECOSYSTEM
- CASIS Executive STEM Workshop
- CASIS Academy Live
- NASA's Kennedy Space Center Community Day
- National Science Teachers Association (NSTA) Regional Conference
- Ottonicon
- Florida Afterschool Alliance Annual Conference


2015 ISS R&D Conference

Targeted R&D Campaigns

As a method to maximize utilization of the ISS National Lab to advance science and technology goals that fulfill national objectives, CASIS has identified priority R&D topics (enabled by access to space) that provide the most value to the nation across a breadth of research disciplines. In particular, CASIS has engaged in two targeted R&D Campaigns to advocate and exercise the utility of the ISS National Lab research platform for high-impact initiatives shared by other government agencies. These two Campaigns, officially kicked off at the close of FY14, are designed to correspond with research objectives of other government agencies and research entities that complement existing ISS National Lab research pathways and engagement strategies.

- GOOD EARTH is a large-scale collaborative campaign focused on maximizing ISS Earth observation capabilities for Earth benefit, with a focus on use of the ISS as a technology demonstration platform. Good Earth will broaden the use of the ISS for imaging Earth by supporting projects that could substantively grow commercial markets supporting global resource exploration and management, humanitarian relief and disaster recovery, and urban and municipal planning and monitoring. CASIS will use relationships with other government agencies (OGAs) and commercial players to facilitate efforts to launch next-generation sensors to the ISS while promoting the use of existing and commercial-off-the-shelf (COTS) hardware. A variety of conferences within this network map were attended as part of Good Earth outreach, and six of the newly awarded projects (in the areas of remote sensing and technology development) fall within this campaign. For additional Good Earth projects, see the Project Pipeline on page 25.
- GOOD HEALTH is an overarching campaign (in partnership with NASA, OGAs, and industry) to leverage funding that will enable open-source science on the ISS to improve human health on Earth. The campaign will generate longitudinal data from model organisms and cell lines exposed to the space environment, which will then be entered into the NASA GeneLab platform (an open-source database of spaceflight data) to enable community-driven reference experiments. The Good Health strategic effort will also leverage the Precision Medicine Initiative, an enterprise to generate the scientific evidence needed to move precision medicine into everyday clinical practice, as well as digital medicine and systems biology to incentivize use of the ISS by the biomedical community. As above, many conferences within this map are related to Good Health outreach, and 23 of the newly awarded projects (in the life and physical sciences as well as technology development) fall within this campaign. For additional Good Health projects, see the Project Pipeline on page 25.

> *"The ISS National Lab is important to my team at MTRI because it provides a cost effective platform to prototype space-based remote sensing systems that address Earth resource issues such as water quality, Great Lake bottom substrate mapping, and land and vegetation characterization."*
> —Dr. Robert Shuchman, Michigan Technological University Research Institute (MTRI)

ACCELERATING DEMAND

The ISS National Lab is a tremendous asset with the ability to empower innovation that will change our world—and increasing awareness of its accessibility and capabilities is paramount to building a sustainable marketplace for space-based R&D. In FY15, CASIS continued to generate interest and demonstrate success in ISS utilization via its multi-pronged approach to engage new users. Targeted outreach and collaboration complemented a variety of research competitions to improve the strategic direction of CASIS toward accomplishing its congressionally mandated mission of diversifying the ISS National Lab R&D portfolio, increasing awareness among the public and our nation's youth, and maximizing ISS utilization for the benefit of life on Earth.

FY15 outreach and engagement had a major focus on building relationships and collaborations to promote quality R&D in space. The ISS National Lab seeks to create opportunities for commercial discovery and applied research in sectors with clear benefit from access to microgravity or the space environment.

Strategic Areas of Focus

Industry Outreach: *CASIS continues commercial market penetration through conference attendance, industry events, and brainstorming sessions with key targeted companies (see page 11).*

- At the close of FY15, such targeted efforts had reached thousands of interested individuals and increased the CASIS pipeline of potential commercial projects to reflect more than 150 companies.
- More than 25 projects awarded by CASIS in FY15 resulted from these strategic efforts.
- Returning customers, such as Merck and Novartis, demonstrate not only that targeted outreach stimulates interest but also that the CASIS customer experience and the power of the ISS National Lab research platform are building a sustainable market.
- For more information on industry targeting in key geographic regions (see page 17).

Key Accounts: *CASIS prioritizes outreach to Fortune 500 companies and other strategic partners with R&D that can be enabled by space.*

- These iconic companies are recognized as leaders in R&D and help build awareness of the ISS National Lab and raise its profile with key stakeholders.
- These companies possess the resources to financially support their own internal development costs and potentially cover the costs associated with space hardware and implementation partners, helping the ISS National Lab leverage its inherent value with external investment.
- Through structured engagement, CASIS works with key accounts to demonstrate the value of the ISS and promote project brainstorming, sponsored program development, and involvement in STEM education initiatives.

TO INFORM THE CASIS IMPLEMENTATION STRATEGY FOR GOOD EARTH, CASIS commissioned a study in FY15 to evaluate the capabilities and limitations of the ISS as an operational host for commercial remote sensing payloads and the products and needs of the data analytics community. Analysis of the gaps within these two areas will inform future ISS National Lab remote sensing and Earth science engagement approaches with other government agencies and large and small aerospace and data analytics companies.

R&D Verticals: *The ISS National Lab supports R&D investigations across a variety of disciplines. To develop and manage a diversified R&D portfolio based on U.S. national needs for basic and applied research, CASIS currently prioritizes outreach in four target verticals.*

- **LIFE SCIENCES:** The ISS National Lab supports R&D in structure-based drug design for more effective therapeutics; accelerated disease modeling to study human illness on Earth, advanced tissue engineering, and regenerative medicine systems; and pharmaceutical inquiries in diagnostics, drug manufacturing, and delivery systems—all capable of improving human health on Earth.
- **PHYSICAL SCIENCES (AND INDUSTRIAL MATERIALS):** Microgravity enables advanced materials production including optical fibers and semiconductors; fundamental physical properties can be studied to improve quality and shelf-life of materials; and the extreme environment of space can induce accelerated material degradation—toward improved materials for consumer products on Earth.
- **REMOTE SENSING (AND EARTH SCIENCE):** The ISS can serve as a testbed for development of sensor assets and a platform for Earth observation, yielding downstream applications in weather monitoring, crop management, water management, urban planning, navigation systems, etc.—toward a better human experience.
- **TECHNOLOGY DEVELOPMENT:** As an orbiting platform, the ISS National Lab is a model for future space-based laboratories and supports studies that may continue in next-generation platforms, including additive manufacturing and bid data management.

Campaigns: *Our two current strategic Campaigns, Good Earth and Good Health (described on page 20), will bring together large-scale collaborations to stimulate ISS utilization over the coming years.*

- **GOOD EARTH** is an international collaboration seeking to maximize ISS Earth observation capabilities for Earth benefit, via the development and deployment of next-generation sensors.
- **GOOD HEALTH** is a grand challenge taken on by CASIS to truly impact human health on Earth—by capitalizing on the unique benefits of the ISS for studying disease transitions, such as osteoporosis and muscle wasting, and for developing means to avert them.

Partnerships and Collaborations

Government Agencies:

- Many of the brainstorming sessions with key accounts this year included collaboration with teams from various NASA centers, furthering CASIS and NASA efforts to exploit shared resources and maximize ISS utilization. This included collaborative execution of a variety of NASA's Destination Station events, the outreach from which resulted in more than 50 new project ideas currently being developed.
- In June, CASIS met with personnel from the NASA Space Life and Physical Sciences Research and Applications Division to define new pathways to mutually support flight projects sponsored by either organization and Reference Missions using model organisms (e.g., rodents). The goal is to accelerate R&D payloads to the ISS within planned research increments. This collaborative and strategic sharing of ISS resources boosts the potential for return on investment to the U.S. taxpayer and benefits the science objectives of both CASIS and NASA.
- CASIS also participated in NASA workshops, including those associated with FluidsLab, CombustionLab, GeneLab, the Human Research Program, and low Earth orbit commercialization efforts.
- The ISS National Lab continues to foster relationships with other government agencies, including the National Institutes of Health and the National Science Foundation, toward development of sponsored programs and other collaborations. Such partnerships and external financial support promote awareness of the value of the ISS research platform and augment the accessibility of this platform to the R&D community beyond the capabilities of CASIS alone.

Investor Forums:

- CASIS cultivated a variety of new investor partnerships with groups interested in supporting cutting-edge R&D, which will seek to further augment available funding avenues for CASIS-sponsored principal investigators.
- In FY15, CASIS facilitated introductions between more than 20 companies and these investor groups—with four companies already attaining investment.

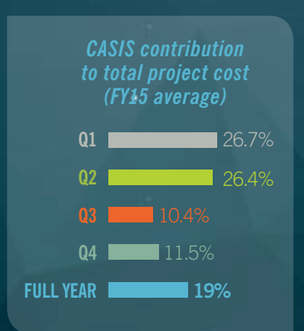
Implementation Partners:

- CASIS continues working with our implementation partners and service providers to expand and improve ISS National Lab customer opportunities.
- Enabling technologies that conserve space, reduce astronaut research time, and increase research capacity are the central themes of this initiative. We are working with our partners to automate experiments, design ISS research hardware that replicates its ground counterpart, and increase opportunities to mount to and deploy from the ISS.
- Technology demonstration and research projects that simultaneously expand ISS National Lab capabilities and grow our customer support options also fall within the scope of this effort. We are evaluating and giving priority to projects that demonstrate an interest and ability to work collaboratively with other planned and ongoing ISS National Lab projects.
- Our goals are to allow more customers to access the ISS National lab, improve the overall customer experience, and ultimately provide the greatest opportunity to develop science and technology advancements that benefit life on Earth.

CASIS presented to more than 400 scientists, technologists, and executives at Merck during a Destination Station outreach event

SPOT LIGHT

Leveraging ISS National Lab Resources



EXTERNAL FINANCIAL SUPPORT of projects demonstrates the value proposition of the ISS National Lab and promotes a sustainable model of space-based research. Each year, CASIS-sponsored research teams are contributing more of their own direct funding and in-kind resources to support their flight projects (for FY15, on average, each organization plans to contribute more than $360,000 to their CASIS project). Cost sharing for CASIS projects selected in FY15 involves these contributions from awarded organizations as well as third-party financial support. Based on estimated cost sharing contributions for FY15-awarded projects, *on average, CASIS awards will contribute only 19% in seed funding toward total projected project costs.*

More specifically, with respect to R&D projects selected/awarded by CASIS in FY15:

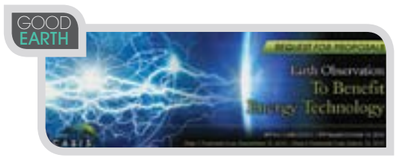
- 35% of projects required no CASIS funding, only ISS National Lab stewardship through CASIS.
- 78% of projects required CASIS seed funding for less than 1/3 of projected project cost.
- Almost 40% of companies have secured some level of third-party funding for their CASIS-sponsored projects (not including NASA grant funding).

RESEARCH COMPETITIONS

In addition to the direct, targeted engagement of key commercial stakeholders,

CASIS participates in formal research and business incubator and accelerator competitions. These efforts further diversify the ISS National Lab portfolio and promote utilization and innovation within priority R&D areas that provide value to the nation. In FY15, CASIS developed and released four competition opportunities across three areas. In addition, CASIS achieved a major success in partnership with the Massachusetts Life Sciences Center (MLSC), who financially supported the first ever CASIS Sponsored Program—a research solicitation fully funded by an outside organization. Finally, CASIS sponsored prizes for two external business accelerator competitions.

Note: STEM Education competitions are described on page 15.



Earth Observation to Benefit Energy Technology

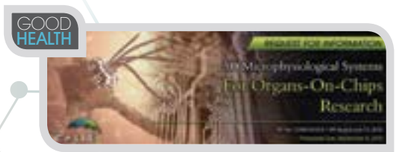
CASIS Request for Proposals

- **OUTCOME:** *Multiple white papers informed CASIS strategy in this sector and project ideas that may be converted into future project opportunities.*
- **POTENTIAL IMPACT:** *Future projects could use Earth imaging from the ISS to identify or improve approaches for energy capture, storage, and/or sustainability on Earth.*

Identification of Animal Models and Cell-based Models for Improved Understanding of Human Disease and Drug Screening on the ISS U.S. National Laboratory

CASIS Request for Information

- **OUTCOME:** *Multiple white papers and community surveys from subject matter experts informed CASIS strategy in identifying optimal models to accelerate space-based research in human disease research, disease modeling, and translational medicine.*
- **POTENTIAL IMPACT:** *Future projects will target at approaches to better understand human disease and medical therapies through use of powerful animal and cell-based models, ultimately leading to new drug treatments and better quality of life for patients.*



3-D Microphysiological Systems for Organs-On-Chips Research (two competitions)

CASIS Request for Information
CASIS Challenge

- **OUTCOME:** *Multiple white papers from subject matter experts in 3-D microphysiological systems informed CASIS strategy, and dozens of proposals are currently under review for a funded flight opportunity (awards expected in early 2016).*
- **POTENTIAL IMPACT:** *Future projects using or improving organs-on-chips research models for fundamental discovery and translational research. The goal of these projects is to provide superior models of how disease afflicts human tissues, helping to accelerate research toward mitigating these effects through disease prevention and novel treatment approaches.*

NASA Astronaut Dan Tani and MLSC President Susan Windham-Bannister at the Galactic Grant press conference.

CASIS selected DexMat, Inc., for flight project development as a part of the Rice Business Plan Competition.

TO SUPPORT THE GALACTIC GRANT COMPETITION ANNOUNCEMENT, CASIS worked with the MLSC to coordinate a press conference with Governor Deval Patrick, Astronaut Dan Tani, and members from the pharmaceutical company Novartis. The event was an incredible success, garnering media features in *The Boston Herald, The Boston Globe*, and National Public Radio.

Galactic Grant Competition

Sponsored Program (grant funding provided by the MLSC)

- **OUTCOME:** *Educated Massachusetts-based life sciences companies on the benefits of space-based R&D and awarded multiple flight projects (via a competitive process) to new-to-space commercial users.*
- **POTENTIAL IMPACT:** *Awarded projects will aim to improve drug development and protection pathogens—toward safer and more efficient pharmaceutical manufacturing and better antibiotics to defeat bacterial drug-resistance.*

IN FY15, CASIS CONTINUED ITS PARTNERSHIP WITH MASSCHALLENGE, the largest startup accelerator to support high-impact, early stage entrepreneurs without taking any equity. During this year's MassChallenge competition, CASIS also partnered (for the second time) with Boeing, which provided $250,000 in funding to support a joint prize with CASIS for innovative flight projects. This commitment from Boeing to support flight projects on the ISS National Lab is an example of success in expanding the CASIS network by leveraging external funding.

Business Accelerators: MassChallenge and Rice Business Plan Competitions

Associated CASIS prize (for MassChallenge, cosponsored with Boeing)

- **OUTCOME:** *Engaged innovative start-up companies focused on breakthrough technologies and awarded multiple flight projects (via a competitive process) to new-to-space entrepreneurs.*
- **POTENTIAL IMPACT:** *Awarded projects will seek commercial solutions to precision medicine: improvements in personalized drug delivery systems (e.g., tunable insulin dosing), point-of-care diagnostics (e.g., testing in a patient's home), and targeted pharmaceuticals with fewer side effects.*

AWARDS FROM COMPETITIONS

In FY15, CASIS also awarded projects resulting from Requests for Proposals (RFPs) issued in FY14. The Materials Science RFP sought flight research investigations focused on developing new or improving existing materials that will have direct terrestrial benefit. The Enabling Technology RFP sought to identify and support technology development projects that would enable increased use of ISS for Earth benefits—for example, improvements in hardware/capabilities or methods to improve bandwidth, throughput, or quality of future research projects.

SNEAK PEEK

FY16 Competitions

A research solicitation planned for FY16 marks another major CASIS success.

IN SEPTEMBER 2015, CASIS FORMALIZED AN AGREEMENT WITH THE NATIONAL SCIENCE FOUNDATION (NSF) that involves $1.8 million in NSF funding for a joint solicitation in support of fluids research on the ISS. This will be the largest Sponsored Program to date for CASIS. Such partnerships and external financial support promote awareness of the value of the ISS research platform and augment the accessibility of this platform to the R&D community beyond the capabilities of CASIS alone.

FY15 SELECTED/ AWARDED PROJECTS

The ISS National Lab portfolio spans multiple disciplines, with projects broadly categorized as life sciences, physical sciences, remote sensing, or technology development. Part of the CASIS mission is to diversify R&D onboard the ISS, so CASIS strives to maintain a balanced portfolio of projects seeking to use the ISS in innovative ways—including support of entrepreneurs, citizen scientists, and other non-traditional users who submit project ideas in response to targeted business development efforts or formal research solicitations/competitions. The following pages describe projects selected or awarded by CASIS in FY15 (via a comprehensive science, operational, and economic review process), in which this diversity of discipline and project origin is evident. *Also denoted is relevance to the current CASIS Campaigns, Good Earth and Good Health, under which more than half of the projects fall.*

Genes in Space
Anna-Sophia Boguraev
Boeing (sponsor) • HOUSTON, TX
SOLICITATION: *Genes in Space Competition*

Student experiment involving DNA amplification using a miniPCR (polymerase chain reaction) machine onboard the ISS. This is the winning student experiment from the Genes in Space innovation challenge. The challenge invited participants to propose pioneering DNA amplification experiments using the unique environment of the ISS.

NDC-3: Chicagoland Boy Scouts and Explorers
Christie Capelety
Three Fires Council of Chicago • CHICAGO, IL
SOLICITATION: *National Design Challenge-3: Chicago*

Student experiment titled "The Impact of Gravity on Arabidopsis Seedlings and Undifferentiated Cells in Space."

NDC-3: Chicagoland Boy Scouts and Explorers
Norman McFarland
Three Fires Council of Chicago • CHICAGO, IL
SOLICITATION: *National Design Challenge-3: Chicago*

Student experiment titled "The Effect of Radiation on Salmonella Bacteria."

NDC-3: Chicagoland Boy Scouts and Explorers
Dr. Sandra Rogers
Three Fires Council of Chicago • CHICAGO, IL
SOLICITATION: *National Design Challenge-3: Chicago*

Student experiment titled "The Impact of Infrared Spectrometer on Alzheimer's Beta-Amyloid Peptide."

NDC-4: Space Station STEM Challenge
Benjamin Coleman
Talbot Middle School • FALL RIVER, MA
SOLICITATION: *Space Station STEM Challenge*

Student experiment titled "Tadpole Morphology and Development in the Presence of UV-B Light in Microgravity."

NDC-4: Space Station STEM Challenge
Matthew Weaver
Collins Middle School • SALEM, MA
SOLICITATION: *Space Station STEM Challenge*

Ground-based student experiment mimicking the Talbot Middle School flight project "Tadpole Morphology and Development in the Presence of UV-B Light in Microgravity."

> *"In terms of the Student Spaceflight Experiments Program, partnership with CASIS has leveraged large-scale STEM education impact, which from CASIS' vantage point is I think enormous progress in addressing its STEM education mandate. The current Mission 9 alone has formally engaged more than 13,000 students.*
> —Dr. Jeff Goldstein, Student Spaceflight Experiments Program (SSEP)

SSEP Mission 7: Odyssey
Dr. Jeff Goldstein
NCESSE/Tides Center

The NanoRacks-National Center for Earth and Space Science Education investigations result from a commercial Science, Technology, Engineering, and Math (STEM) education program overseen by the National Center for Earth and Space Science Education (NCESSE), called the Student Spaceflight Experiments Program (SSEP). Student teams from across the United States design their own experiments using flight approved fluids and materials. The investigation consists of multiple science experiments flown in a NanoRacks Module onboard the ISS.

ARISS (Amateur Radio from ISS)
Frank Bauer
AMSAT (Radio Amateur Satellite Corporation)
KENSINGTON, MD

ARISS is an international working group formed in 1996 by request from NASA. NASA's vision was for ARISS to be a single internationally coordinated entity that would develop, operate, and conduct educational outreach on the ISS. In this way, a single focus and entry point would be created for all amateur radio activities on the ISS. Students are able to talk directly to astronauts on the ISS as a culminating educational activity. In preparation, students learn about radio communications, space technology, science experiments on the ISS, geography, and the space environment.

NASA HUNCH
David Schlichting
Eaglecrest High School • CENTENNIAL, CO

Student experiment to analyze the three-dimensional structure of silver crystals in microgravity, compared to 1g, to determine whether elimination of gravity produces higher-quality crystals.

SSEP Mission 8: Kitty Hawk
Dr. Jeff Goldstein
NCESSE/Tides Center

The NanoRacks-National Center for Earth and Space Science Education investigations result from a commercial Science, Technology, Engineering, and Math (STEM) education program called the Student Spaceflight Experiments Program (SSEP), which is overseen by the National Center for Earth and Space Science Education (NCESSE). Student teams from across the United States design their own experiments using flight-approved fluids and materials. The investigation consists of multiple science experiments flown in a NanoRacks Module onboard the ISS.

Efficacy & Metabolism of Azonafide Antibody-Drug Conjugates (ADCs)
Sourav Sinha
Oncolinx • BOSTON, MA
SOLICITATION: *Mass Challenge*

Test the efficacy and drug metabolism of Azonafide ADCs in microgravity 3-D cell cultures. Cultures in microgravity should serve as better in vivo models of tumors than terrestrial cultures and, as such, accelerate the timeline to translational applications of the research. ADCs are toxic therapeutics that target tumors through receptors on the surface of cancer cells, thereby reducing toxicity and increasing effectiveness of the therapy.

Capillary-Driven Microfluidics in Space
Dr. Luc Gervais
1Drop Diagnostics • BOSTON, MA
SOLICITATION: *Mass Challenge*

Perform capillary-driven microfluidics experiments in space. Experiments will include capillary filling of microstructures, particle focusing and plasma separation, and microfluidic flow in thermal gradients. It will be quantified using fluorescent biochemical reactions. This project will bring a new understanding of the capillary flow of fluids on a micrometer scale.

Intracellular Macromolecule Delivery and Cellular Biomechanics in Microgravity
Harrison Bralower
SQZ Biotechnologies • SOMERVILLE, MA
SOLICITATION: *Mass Challenge*

Investigate the effects of microgravity on an experimental technology called the CellSqueeze platform. This technology provides a novel method for delivering large molecules into targeted cells by using a microfluidic chip to physically squeeze cells. The CellSqueeze platform opens pores in the cell membrane without harming the cell in order to increase the efficiency of molecule delivery by 10- to 100-fold over current techniques. This research may even lead to improved tissue engineering capabilities and advances in regenerative medicine.

The Effect of Microgravity on Stem-Cell Mediated Recellularization
Dr. Jason Sakamoto
The Methodist Hospital Research Institute • HOUSTON, TX
SOLICITATION: *Stem Cell Request for Proposals*

Study the effects of microgravity and radiation on mesenchymal stem cells grown on a novel scaffold of human acellularized lung tissue. More deeply understanding the kinetics and mechanisms of delivery and bio-distribution of the particles used for nanovector delivery of critical growth factors may impact how to administer these particles on Earth. The knowledge provided by this study will develop a stem cell mediated regeneration capability for human acellular lungs to engineer a functional new organ.

LEGEND

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FY15 SELECTED/AWARDED PROJECTS

GOOD HEALTH

Nanobiosym-Galactic Grant
Dr. Anita Goel
Nanobiosym • CAMBRIDGE, MA
SOLICITATION: *Galactic Grant Competition*

Perform a proof-of-concept study to computationally predict bacterial mutations and to evaluate model organisms in space, and use the empirical results to validate and refine predictive algorithms. This proof-of-concept experiment will provide data that can be applied to future predictive models for antibiotic-resistant pathogen mutations, which will be of significant value to antibiotic drug development.

GOOD HEALTH

Reduced Oxidative Damage During Spaceflight (RODS)
Carlos Montesinos
AstroMed Research Institute • KATY, TX

Investigate the use of a dietary supplement to mitigate the effects of oxidative damage due to stress, radiation exposure, and microgravity exposure.

GOOD HEALTH

Osteocyte Response to Mechanical Forces (Osteo-4)
Dr. Paola Divieti Pajevic
Boston University • BOSTON, MA

Study the effects of microgravity on the function of osteocytes, the most common cells in bone. These cells reside within the mineralized bone and can sense mechanical forces, or lack of forces, but researchers do not know how. Osteo-4 allows scientists to analyze changes in the physical appearance and genetic expression of mouse bone cells in microgravity.

GOOD HEALTH

Cranial Bone Marrow Stem Cell Culture in Space
Dr. Yang (Ted) D. Teng and Dr. Louis Yuge
Brigham and Women's and Space Bio Laboratories Co., Ltd.
BOSTON, MA

Clarify microgravity's effects on the growth and differentiation of human cranial mesenchymal stromal stem cells (hCMSCs). The undifferentiated state of hCMSCs advocates pluripotency that enables efficient recovery from neural damage. Microgravity provides an advantage to produce pluripotent stem cells without any potential risk of genetic manipulations and chemical contamination.

GOOD HEALTH

Eli Lilly PCG
Kristofer R. Gonzalez-DeWhitt, Michael Hickey
Eli Lilly and Company • INDIANAPOLIS, IN

A two-part experimental design in conjunction with a parallel set of Earth-based controls (also, a two-part design) will be followed to examine the crystallization of medically-relevant protein-ligand complexes in microgravity.

GOOD HEALTH

Growth Rate Dispersion as a Predictive Indicator for Biological Crystal Samples
Dr. Edward Snell
Hauptman Woodward Medical Research Institute, Inc.
BUFFALO, NY

Validate the hypothesis that growth rate dispersion could be an indicator of crystals whose quality could be improved in microgravity. Growth rate dispersion is a phenomenon encountered in crystallization in which seemingly identical crystals produced from the same conditions grow at different rates. It is contended that large growth rate dispersion on the ground is indicative of a sample that should be improved by microgravity growth. Protein crystal growth (PCG) is a foundational element of R&D on the ISS for drug discovery, drug formulation, drug delivery, and disease modeling.

GOOD HEALTH

Eli Lilly-RR3 Myostatin
Dr. Rosamund Smith
Eli Lilly and Company • INDIANAPOLIS, IN

Determine the impact of an anti-myostatin antibody on muscle wasting in the absence of artificial constraints or comorbidities that could interfere with the interpretation of results.

GOOD HEALTH

Rodent Research-4 Validation Study
Dr. Melissa Kacena
Indiana University Research • INDIANAPOLIS, IN

Validation that mice can successfully undergo an orthopaedic surgery (segmental bone defect) and be housed at high densities under conditions akin to that of spaceflight hardware, and withstand the forces of gravity and vibration experienced during launch as well as the stresses associated with unloading.

GOOD HEALTH

Molecules Produced in Microgravity from the Chernobyl Nuclear Accident
Dr. Kasthuri Venkateswaran
Jet Propulsion Laboratory/Caltech • PASADENA, CA

Fungal strains isolated from the Chernobyl nuclear powerplant (ChNPP) accident will be screened for the secretion of natural products that could be beneficial for biomedical and agricultural applications. Because fungal strains isolated in and around the ChNPP produce agro- and pharma-related natural products on Earth, the team proposes to test the fungal cells under stressful microgravity conditions to measure whether they can produce novel secondary metabolites.

GOOD HEALTH

T-Cell Activation in Aging
Dr. Millie Hughes-Fulford
Northern California Institute for Research and Education, Inc. • SAN FRANCISCO, CA

Elucidate the defect in T-cell activation, an immune response used to fight foreign antigens, during microgravity exposure. Scientists hope to pinpoint key elements required for a normal immune response in order to gain a better understanding of the declining immune function during the aging process. Discoveries from this investigation may lead to the development of medical treatments to maintain normal immune function throughout life on Earth and in space.

GOOD HEALTH

Soluble Corn Fiber to Improve Bone Mineral Density
Dr. Patricia Williamson
Tate & Lyle • HOFFMAN ESTATES, IL

Demonstrate that Tate & Lyle's PROMITOR® Soluble Corn Fiber (SCF), a commercially available food ingredient, can enhance bone health of individuals on Earth by using spaceflight as a model of accelerated aging. Bone loss occurs about 10 times faster in space than on Earth, so significant effects can be seen in a shorter period of time.

GOOD HEALTH

The Effect of Macromolecular Transport on Microgravity PCG
Dr. Lawrence DeLucas
University of Alabama at Birmingham
BIRMINGHAM, AL

Validate the hypothesis that the improved quality of microgravity-grown biological crystals is the result of two macromolecular characteristics that exist in a buoyancy-free, diffusion-dominated solution: 1) slower crystal growth rates due to slower protein transport to the growing crystal surface, and 2) predilection of growing crystals to incorporate protein monomers versus higher protein aggregates due to differences in transport rates. Improved understanding of fluid dynamics and reaction kinetics in microgravity will improve mathematical models of protein crystal growth that will promote utilization of the ISS for drug discovery.

GOOD HEALTH

Characterizing Arabidopsis Root Attractions (CARA) Grant Extension Request
Dr. Anna-Lisa Paul
University of Florida • GAINESVILLE, FL

Grant Extension: Growth and development of *Arabidopsis thaliana* seedlings in the spaceflight environment. Researchers seek to identify the genes involved in plant root morphology and adaptive physiology; specifically, how a root knows in which direction to grow when gravity is absent. Results will expand on those of previous ISS research in this area and further the study of specific molecular pathways involved in plant adaptive physiology on Earth.

GOOD HEALTH

Zaiput Flow Technologies-Galactic Grant
Dr. Andrea Adamo
Zaiput Flow Technologies • CAMBRIDGE, MA
SOLICITATION: *Galactic Grant Competition*

Explore the effects of gravity on Zaiput's device for continuous separation of immiscible liquids. While common separation methods rely on liquid sedimentation, their system has the unique characteristic of relying on surface forces to accomplish liquid-liquid extraction. To serve the needs of chemical production, the device needs to be scaled up, which requires understanding the effect that gravity and length scales have on the flow path as it relates to separation efficiency.

GOOD HEALTH

Electrolytic Gas Evolution Under Microgravity
Larry Alberts
Cam Med, LLC • BOSTON, MA
SOLICITATION: *Mass Challenge*

Examine the use of electrolysis to generate bubbles to improve methods of drug delivery and precision dosage control in CamMed's Evopump. The Evopump is a small, bandage-like pump that can deliver medications directly through the skin. Examining bubble formation and release from an electrode in the low fluid shear environment of the ISS will provide data relevant for multiple industries, including medical device manufacturers and pharmaceutical companies. The Evopump has many applications on Earth because its convenience and small size overcome many of the obstacles that discourage patients from using pumps for continuous controlled delivery of medications such as insulin.

Survivability of Variable Emissivity Devices for Thermal Control Applications
Dr. Hulya Demiryont
Eclipse Energy Systems, Inc. • ST. PETERSBURG, FL
SOLICITATION: *Materials Science Request for Proposals*

Examine how variable emissivity devices (VEDs) interact with the punishing environment of space. VEDs could be used on Earth in energy-saving smart-roofing technology that would switch from blocking heat in the summer months to passing heat in the winter months in order to reduce heating and cooling costs.

Detached Melt and Vapor Growth of InI in SUBSA Hardware
Dr. Aleksandar Ostrogorsky
Illinois Institute of Technology • CHICAGO, IL
SOLICITATION: *Materials Science Request for Proposals*

Synthesize new types of semiconductor crystals on the ISS to show that this material can positively compare with other semiconductor materials. It is non-toxic and can be grown at a much faster rate than other semiconductor materials.

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FY15 SELECTED/AWARDED PROJECTS

Crystal Growth of Cs2LiYCl6:Ce Scintillators in Microgravity
Dr. Alexei Churilov
Radiation Monitoring Devices, Inc. • WATERTOWN, MA
SOLICITATION: *Materials Science Request for Proposals*

Conduct a series of experiments on the ISS to grow scintillator crystals. Scintillators excite when exposed to certain types of radiation. They can be used in detectors, primarily for homeland security applications.

Eli Lilly–Dissolution of Hard to Wet Solids
Dr. Richard Cope, Dr. Alison Campbell, Dr. Kenneth Savin
Eli Lilly and Company • INDIANAPOLIS, IN

Evaluate the role of microgravity on wettability and ultimate dissolution rates to gain a better understanding of fundamental processes. Many active pharmaceutical ingredients and excipients commonly used in formulating modern-day pharmaceuticals are characterized as hard-to-wet solids. As such, they represent a challenge to their ultimate pharmaceutical effectiveness as well as their development and manufacturing.

Eli Lilly–Lyophilization
Jeremy Hinds, Dr. Evan Hetrick
Eli Lilly and Company • INDIANAPOLIS, IN

Examine the influence of gravity on the physical state and properties of lyophilized materials of interest in the pharmaceutical industry. Lyophilization (i.e., freeze-drying) is a common method for formulating pharmaceutical drug products with improved chemical and physical stability and is applicable to both small and large molecule pharmaceutical products.

Nemak Alloy Solidification Experiments
Dr. Glenn Byczynski
NEMAK • SOUTHFIELD, MI

Elucidate critical parameters behind the formation of hot tearing by removing gravitational effects from the process and observing which phenomena and parameters emerge as dominant.

Nanofluidics – Reflight
Dr. Alessandro Grattoni
The Methodist Hospital Research Institute • HOUSTON, TX

Modification to original project for reflight (payload was lost on SpX-7). Examine the mechanisms of molecule transport across nanochannel membranes. These membranes can be developed for passive and active release of molecules, drugs, and nanoparticles using implants placed in the human body. The study examines these phenomena over an extended period of time.

Faraday Waves and Instability-Earth and Low G Experiments
Dr. Ranga Narayanan
University of Florida • GAINESVILLE, FL

Study of the instability of an interface between two liquids with different densities under vibrational acceleration (Faraday Instability). This instability is an important way to induce mixing, such as in microfluidic processing of pharmaceuticals, and to dislodge persistent drops or bubbles on surfaces.

Space Based Optical Tracker
Dr. John Stryjewski
Vision Engineering Solutions • ORLANDO, FL

Test a novel approach to track spacecraft, debris, and objects that have little to no radar cross-section (for collision avoidance in future satellite and commercial spacecraft applications).

CyMISS Grant Proposal for the 2015 Tropical Cyclone Season – Reflight
Dr. Paul Joss
Visidyne, Inc. • BURLINGTON, MA

Develop technology to measure maximum wind speeds within mature tropical cyclones from the ISS. This platform technology will have great interest for coastal regions at high risk for tropical cyclone landfalls.

Controlled Dynamics Locker for Microgravity Experiments on ISS
Dr. Scott A. Green
Controlled Dynamics, Inc. • HUNTINGTON BEACH, CA
SOLICITATION: *Enabling Technologies Request for Proposals*

Develop an insert for existing ISS hardware that will provide research payloads with a "controlled dynamic acceleration environment;" in other words, a technology that will dampen fluctuations and disturbances in the microgravity environment that occur onboard moving spacecraft. This technology promises to attract a new class of research experiments and private funding aimed at exploiting this controlled acceleration environment in microgravity, which has the potential to improve space experiments in crystallization; cell, tissue, and plant culturing; and other studies.

Spacecraft-on-a-Chip Experiment Platform
Dr. Mason Peck
Cornell University • ITHACA, NY
SOLICITATION: *Enabling Technologies Request for Proposals*

Adapt a spacecraft-on-a-chip experimental satellite platform called Sprite to eventually be programmed in place and deployed from the ISS. This would provide a low-cost, rapidly-deployable, crew-configurable small-satellite platform for science and technology development. Expected users of this technology include those in the GPS, space tourism, entertainment, and DIY space industries.

Improving Astronaut Performance of National Lab Research Tasks
Dr. Jayfus Doswell
Juxtopia, LLC • BALTIMORE, MD
SOLICITATION: *Enabling Technologies Request for Proposals*

Develop and evaluate an innovative augmented reality (AR) goggle and software system, the Juxtopia Context-Aware Mobile Mixed Reality Assistive Device (CAMMRAD). These AR goggles will provide virtual assistance that seeks to improve the speed and accuracy with which astronauts perform ISS National Lab science experiments. Moreover, Earth-based markets for this product exist in emergency response organizations that employ first responders who work in remote, austere, or extreme environments.

MultiLab: Research Server for the ISS
Twyman Clements
Space Tango, Inc. • LEXINGTON, KY
SOLICITATION: *Enabling Technologies Request for Proposals*

The MultiLab is an EXPRESS Rack Locker facility to be permanently installed on the ISS that will serve as a multi-use general-purpose research platform built for commercial, academic, and government use. The MultiLab is one part of a larger grouping of technology and services Space Tango, Inc. has brought together to lower barriers of design and increase end-user interaction with their research and the ISS.

Map the Penetration Profile of a Contact-Free Transdermal Drug Delivery System
Dr. Robert Applegate
Novopyxis • BOSTON, MA
SOLICITATION: *Mass Challenge*

Improve a patent-pending device, Droplette, for drug delivery directly through skin contact. Droplette can deliver drug molecules up to 60% larger than current topical treatments deep into the skin over broad or uneven surface areas. By studying how the drugs penetrate and spread once they have entered a matrix mimicking human skin, the company may be able to improve the accuracy of drug delivery. Performing these studies in the absence of gravity will give a more accurate representation of how the drug penetration process works in the human body.

SiC Microgravity Enhanced Electrical Performance (MEEP)
Rich Glover
ACME Advanced Materials • ALBUQUERQUE, NM

Perform long-duration microgravity processing to determine whether spaceflight reduces defects in SiC-semiconductor substrates and epitaxial layers more significantly than modeled microgravity. SiC is a near-perfect semiconductor material, but applications to large-scale devices have thus far been limited by the inability to make substrates and layers sufficiently free of defects.

The Universal Manufacture of Next Generation Electronics
Dr. Supriya Jaiswal
Astrileux Corporation • LA JOLLA, CA

Develop new smaller extreme ultraviolet (EUV) optics, which will provide the foundation for optical systems used in solar radiation imaging, ground based telescopes, and satellites. These optics will enable illumination systems with higher resolution and a more compact design. The long-term exposure to the EUV radiation environment of space allows for accelerated degradation testing of these optical materials.

SG100 Cloud Computing Payload
Trent Martin
Business Integra • HOUSTON, TX

Technology-readiness-level (TRL) advancement of SG100, a single-board computer platform that can support the much higher processor demands of the current and future scientific and aerospace applications in low Earth orbit. The test period will be 2 years, with interim data reports at 6-month intervals–culminating in achievement of TRL 9. The technology will provide a low risk solution to satellite and experiment developers.

Providing Spherical Video Tours of ISS
David Gump
Deep Space Industries • MOFFETT FIELD, CA

Capture content on the ISS via immersive spherical video technology.

D-Sat Active Decommissioning Demonstration
Dr. Luca Rossettini
D-Orbit • LOS ANGELES, CA

Demonstrate a full controlled-quick-and-safe reentry of a low Earth orbit satellite through the D-Orbit decommissioning device.

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CURRENT ISS NATIONAL LAB

PROJECT PIPELINE *(as of Sept. 30, 2015)*

CASIS has existed as an organization for only four years, but in that time, the ISS National Lab portfolio selected and awarded by CASIS has grown to include 100 projects from commercial companies, academic and nonprofit institutions, and non-NASA government agencies. In addition, CASIS has supported or selected more than 60 projects involving grade-school level educational initiatives and dozens of projects from the commercial service provider NanoRacks, LLC*. The following pages contain a snapshot of where CASIS-sponsored projects are in the pipeline—ground validation studies, preflight project development, in-flight payload execution, or postflight analysis/completion.

GROUND

Longitudinal Assessment of Intracranial Pressure During Prolonged Spaceflight
Dr. Clifford Dasco • Baylor College of Medicine

Generation of Cardiomyocytes from Human iPS Cell-derived Cardiac Progenitors
Dr. Chunhui Xu • Emory University

Examine Bone Tumor and Host Tissue Interactions Using Microgravity Bioreactors
Dr. Carl Gregory • Texas A&M Health Science Center

Generation of Mesendoderm Stem Cell Progenitors in the ISS-National Laboratory
Dr. Robert Schwartz • University of Houston

Viral Infection Dynamics and Inhibition by the Vecoy Nanotechnology
Dr. Drew Cawthon • Lovelace Respiratory Research Institute

Optimizing Jammable Granular Assemblies in a Microgravity Environment
Jason Hill • Benevolent Technologies for Health

Microbead Fabrication using Rational Design Engineering
Dr. Brian Plouffe • Quad Technologies

Great Lakes Specific HICO Water Quality Algorithms
Dr. Robert Shuchman • Michigan Technological University

Hyperspectral Remote Sensing of Terrestrial Ecosystem Carbon Fluxes
Fred Huemmrich • University of Maryland Baltimore County

HICO Identification of Harmful Algal Blooms
Dr. Richard Becker • University of Toledo

Spacecraft-on-a-Chip Experiment Platform
Dr. Mason Peck • Cornell University

Improving Astronaut Performance of National Lab Research Tasks
Dr. Jayfus Doswell • Juxtopia, LLC

PREFLIGHT

Story Time From Space
Patricia Tribe • T2 Science and Math Education Consultants
PLANNED LAUNCH VEHICLE: *Orb-4*

SSEP-Odyssey
Dr. Jeff Goldstein • NCESSE/Tides Center
PLANNED LAUNCH VEHICLE: *SpX-8*

HUNCH Chlorella/Billings Central Catholic High
Dr. Florence Gold • Rocky Mountain College
PLANNED LAUNCH VEHICLE: *SpX-8*

Genes In Space
Anna-Sophia Boguraev • Boeing (sponsor)
PLANNED LAUNCH VEHICLE: *SpX-9*

NDC-3: Chicagoland Boy Scouts and Explorers
Christie Capelety • Three Fires Council of Chicago
PLANNED LAUNCH VEHICLE: *SpX-11*

NDC-3: Chicagoland Boy Scouts and Explorers
Norman McFarland • Three Fires Council of Chicago
PLANNED LAUNCH VEHICLE: *SpX-11*

NDC-3: Chicagoland Boy Scouts and Explorers
Dr. Sandra Rogers • Three Fires Council of Chicago
PLANNED LAUNCH VEHICLE: *SpX-11*

Zero Robotics – Middle School Competition
Dr. Alvar Saenz Otero • Massachusetts Institute of Technology
PLANNED LAUNCH VEHICLE: *yearly*

Zero Robotics – High School Competition
Dr. Alvar Saenz Otero • Massachusetts Institute of Technology
PLANNED LAUNCH VEHICLE: *yearly*

Use of Boron-Enhanced High-Density Polyethylene for Radiation Shielding – NDC Pilot potential reflight
Angela Glidewell • Awty International School
PLANNED LAUNCH VEHICLE: *TBD*

Carbon Dioxide Emissions of Yeast Cells in Microgravity Environment – NDC Pilot potential reflight
Jessika Smith • Awty International School
PLANNED LAUNCH VEHICLE: *TBD*

NDC Pilot Program – potential reflight
Rev. Brian Reedy • Cristo Rey Jesuit College Preparatory of Houston
PLANNED LAUNCH VEHICLE: *TBD*

NDC Pilot Program – potential reflight
Greg Adragna • Cristo Rey Jesuit College Preparatory of Houston
PLANNED LAUNCH VEHICLE: *TBD*

The Effects of Microgravity and Light Wavelength on Plant Growth – NDC Pilot potential reflight
Kathy Duquesnay • Duchesne Academy
PLANNED LAUNCH VEHICLE: *TBD*

The Effects of Different Wavelengths of Light on Algae Oxygen Production in Microgravity – NDC Pilot potential reflight
Susan Knizner • Duchesne Academy
PLANNED LAUNCH VEHICLE: *TBD*

NDC-2 (Denver) – potential reflight
Brian Thomas • Centaurus High School
PLANNED LAUNCH VEHICLE: *TBD*

NDC-2 (Denver) – potential reflight
Shanna Atzmiller • Bell Middle School
PLANNED LAUNCH VEHICLE: *TBD*

NDC-2 (Denver) – potential reflight
Joel Bertelsen • Chatfield Senior High School
PLANNED LAUNCH VEHICLE: *TBD*

Eli Lilly PCG
Kristofer R. Gonzalez-DeWhitt, Michael Hickey
Eli Lilly and Company
PLANNED LAUNCH VEHICLE: *SpX-8*

Eli Lilly-RR3 Myostatin
Dr. Rosamund Smith • Eli Lilly and Company
PLANNED LAUNCH VEHICLE: *SpX-8*

Molecules Produced in Microgravity from the Chernobyl Nuclear Accident
Dr. Kasthuri Venkateswaran • Jet Propulsion Laboratory/Caltech
PLANNED LAUNCH VEHICLE: *SpX-9*

Functional Effects of Spaceflight on Cardiovascular Stem Cells
Dr. Mary Kearns-Jonker • Loma Linda University
PLANNED LAUNCH VEHICLE: *SpX-9*

NIH-Osteo
Dr. Bruce Hammer • University of Minnesota
PLANNED LAUNCH VEHICLE: *SpX-10*

Effects of Microgravity on Stem Cell-Derived Heart Cells
Dr. Joseph Wu • Stanford University
PLANNED LAUNCH VEHICLE: *SpX-9*

Growth Rate Dispersion as a Predictive Indicator for Biological Crystal Samples
Dr. Edward Snell
Hauptman Woodward Medical Research Institute, Inc.
PLANNED LAUNCH VEHICLE: *SpX-8*

Application of Microgravity Expanded Stem Cells in Regenerative Medicine
Dr. Abba Zubair • Mayo Clinic
PLANNED LAUNCH VEHICLE: *SpX-10*

The Effect of Macromolecular Transport on Microgravity PCG
Dr. Lawrence DeLucas • University of Alabama at Birmingham
PLANNED LAUNCH VEHICLE: *SpX-10*

Rodent Research-4 Validation Study
Dr. Melissa Kacena • Indiana University School of Medicine
PLANNED LAUNCH VEHICLE: *SpX-10*

Nanobiosym- Galactic Grant
Dr. Anita Goel • Nanobiosym
PLANNED LAUNCH VEHICLE: *SpX-13*

Capillary-Driven Microfluidics in Space
Dr. Luc Gervais • 1Drop Diagnostics U.S., Inc.
PLANNED LAUNCH VEHICLE: *TBD*

Cranial Bone Marrow Stem Cell Culture in Space
Dr. Yang (Ted) D. Teng • Brigham and Women's and Space Bio Laboratories Co., Ltd
PLANNED LAUNCH VEHICLE: *TBD*

Efficacy & Metabolism of Azonafide Antibody-Drug Conjugates (ADCs)
Sourav Sinha • Oncolinx
PLANNED LAUNCH VEHICLE: *TBD*

Intracellular Macromolecule Delivery and Cellular Biomechanics in Microgravity
Harrison Bralower • SQZ Biotechnologies
PLANNED LAUNCH VEHICLE: *TBD*

Soluble Corn Fiber to Improve Bone Mineral Density
Patricia Williamson • Tate & Lyle
PLANNED LAUNCH VEHICLE: *TBD*

The Effect of Microgravity on Stem Cell Mediated Recellularization
Jason Sakamoto • The Methodist Hospital Research Institute
PLANNED LAUNCH VEHICLE: *TBD*

Systemic Therapy of NELL-1 for Osteoporosis
Dr. Chia Soo • UCLA
PLANNED LAUNCH VEHICLE: *TBD*

Characterizing Arabidopsis Root Attractions (CARA) grant extension request
Dr. Anna-Lisa Paul • University of Florida
PLANNED LAUNCH VEHICLE: *TBD*

Milliken: Vertical Burn
Dr. Jeff Strahan • Milliken
PLANNED LAUNCH VEHICLE: *Orb-4*

Corrosion Inhibitor Exposed to the Extreme Environments in Space
Lauren Thompson Miller • A-76 Technologies, LLC
PLANNED LAUNCH VEHICLE: *TBD*

Survivability of Variable Emissivity Devices for Thermal Control Applications
Dr. Hulya Demiryont • Eclipse Energy Systems, Inc.
PLANNED LAUNCH VEHICLE: *TBD*

Detached Melt and Vapor Growth of InI in SUBSA Hardware
Dr. Aleksandar Ostrogorsky • Illinois Institute of Technology
PLANNED LAUNCH VEHICLE: *TBD*

Nemak Alloy Solidification Experiments
Dr. Glenn Byczynski • NEMAK
PLANNED LAUNCH VEHICLE: *TBD*

Crystal Growth of Cs2LiYCl6:Ce Scintillators in Microgravity
Dr. Alexei Churilov • Radiation Monitoring Devices, Inc.
PLANNED LAUNCH VEHICLE: *TBD*

Faraday Waves and Instability-Earth and Low G Experiments
Dr. Ranga Narayanan • University of Florida
PLANNED LAUNCH VEHICLE: *TBD*

Materials Testing: The Evaluation of Gumstix Modules in Low Earth Orbit
Dr. Kathleen Morse • Advanced Materials Applications, LLC
PLANNED LAUNCH VEHICLE: *SpX-8*

Materials Testing – Earth Abundant Textured Thin Film Photovoltaics
Dr. Jud Ready • Georgia Institute of Technology
PLANNED LAUNCH VEHICLE: *SpX-8*

Decoupling Diffusive Transport Phenomena in Microgravity
Dr. Alessandro Grattoni
The Methodist Hospital Research Institute
PLANNED LAUNCH VEHICLE: *SpX-8*

Electrolytic Gas Evolution under Microgravity
Larry Alberts • Cam Med, LLC
PLANNED LAUNCH VEHICLE: *TBD*

Eli Lilly–Dissolution of Hard-to-Wet Solids
Dr. Richard Cope, Dr. Alison Campbell, Dr. Kenneth Savin
Eli Lilly and Company
PLANNED LAUNCH VEHICLE: *TBD*

Eli Lilly–Lyophilization
Jeremy Hinds, Dr. Evan Hetrick • Eli Lilly and Company
PLANNED LAUNCH VEHICLE: *TBD*

Zaiput Flow Technologies-Galactic Grant
Dr. Andrea Adamo • Zaiput Flow Technologies
PLANNED LAUNCH VEHICLE: *TBD*

Project Meteor
Michael Fortenberry • Southwest Research Institute
PLANNED LAUNCH VEHICLE: *SpX-9*

MUSES Imaging Platform
Bill Corley • Teledyne Brown Engineering
PLANNED LAUNCH VEHICLE: *SpX-11*

Space Based Optical Tracker
Dr. John Stryjewski • Vision Engineering Solutions
PLANNED LAUNCH VEHICLE: *TBD*

Development and Deployment of Charge Injection Device Imagers
Dr. Daniel Batcheldor • Florida Institute of Technology
PLANNED LAUNCH VEHICLE: *TBD*

Space Based Optical Tracker
Dr. John Stryjewski • Vision Engineering Solutions
PLANNED LAUNCH VEHICLE: *TBD*

MultiLab: Research Server for the ISS
Twyman Clements • Space Tango, Inc.
PLANNED LAUNCH VEHICLE: *SpX-9*

Controlled Dynamics Locker for Microgravity Experiments on ISS
Dr. Scott A. Green • Controlled Dynamics, Inc.
PLANNED LAUNCH VEHICLE: *OA-5*

SiC Microgravity Enhanced Electrical Performance (MEEP)
Rich Glover • ACME Advanced Materials
PLANNED LAUNCH VEHICLE: *TBD*

The Universal Manufacture of Next Generation Electronics
Dr. Supriya Jaiswal • Astrileux Corporation
PLANNED LAUNCH VEHICLE: *TBD*

Providing Spherical Video Tours of ISS
Mr. David Gump • Deep Space Industries
PLANNED LAUNCH VEHICLE: *TBD*

Intuitive Machines-ISS Terrestrial Return Vehicle (TRV)
Steve Altemus • Intuitive Machines
PLANNED LAUNCH VEHICLE: *TBD*

Zero-G Characterization & On-Orbit Assembly for Cellularized Satellite Tech
Talbot Jaeger • NovaWurks, Inc.
PLANNED LAUNCH VEHICLE: *Orb-4*

Demonstration and TRL Raising of the Net Capture System on the ISS
Ron Dunklee • AIRBUS DS Space Systems, Inc.
PLANNED LAUNCH VEHICLE: *SpX-9*

Global AIS on Space Station (GLASS)
Robert Carlson • JAMSS America, Inc. (JAI)
PLANNED LAUNCH VEHICLE: *SpX-9*

SG100 Cloud Computing Payload
Trent Martin • Business Integra
PLANNED LAUNCH VEHICLE: *TBD*

Six CASIS National Design Challenge (NDC) educational experiments from three Houston-area schools were lost in the Orb-3 launch anomaly. Seven NDC experiments (four from Houston and three from Colorado) were lost in the SpX-7 anomaly, along with 25 total student experiments from the Student Spaceflight Experiments Program. In addition, ten NanoRacks-sponsored projects and two CASIS-sponsored R&D payloads, Project Meteor (from Michael Fortenberry of Southwest Research Institute) and Decoupling Diffusive Transport Phenomena in Microgravity (from Dr. Alessandro Grattoni of the Methodist Hospital Research Institute), were also lost in the SpX-7 anomaly.

LEGEND

EDUCATION · PHYSICAL SCIENCES · TECHNOLOGY DEVELOPMENT · LIFE SCIENCES · REMOTE SENSING

*Although part of the ISS National Lab R&D portfolio, NanoRacks projects are not detailed here in the CASIS project pipeline.

CURRENT ISS NATIONAL LAB

PROJECT PIPELINE *(as of Sept. 30, 2015)*

PREFLIGHT *(continued)*

Honeywell/Morehead-DM Payload Processor
Dr. Benjamin Malphrus • Honeywell/Morehead State University
PLANNED LAUNCH VEHICLE: *TBD*

Magnetic 3-D Cell Culture for Biological Research in Microgravity
Dr. Glauco Souza • Nano3D Biosciences, Inc.
PLANNED LAUNCH VEHICLE: *SpX-11*

Ultra-Portable Remote-Controlled Microfluidics Microscopy Microenvironment
Dan O'Connell • HNu Photonics
PLANNED LAUNCH VEHICLE: *TBD*

Map the Penetration Profile of a Contact-Free Transdermal Drug Delivery System
Dr. Robert Applegate • Novopyxis
PLANNED LAUNCH VEHICLE: *TBD*

IN-FLIGHT

Binary Colloidal Alloy Test – Low Gravity Phase Kinetics Platform
Dr. Matthew Lynch • Procter & Gamble, with Zin Technologies, Inc.

Synthetic Muscle: Resistance to Radiation
Dr. Lenore Rasmussen • Ras Labs

Espresso Cup
Dr. Mark Weislogel • IRPI LLC

Windows On Earth
Dan Barstow • TERC

National Lab Project: AMS
Dr. Samuel Ting • Department of Energy

National Lab Projects: ISERV
Burgess Howell • Disaster Relief Charter

Bone Densitometer
John Vellinger • Techshot, Inc.

POSTFLIGHT

Ants in Space, CSI-06
Stefanie Countryman • BioServe Space Technologies

Omega Hydrofuge Plant Growth Chamber – HUNCH Extreme Science – Lakewood
Matthew Brown • Lakewood High School

Zero Robotics – Middle and High School Competitions
Dr. Alvar Saenz Otero
Massachusetts Institute of Technology Education

NCESSE/SSEP (Student Spaceflight Experiments Program) – Orion, Falcon, Mixture Tube, Yankee Clipper
Dr. Jeff Goldstein • NCESSE/Tides Center

Osteocytes and Mechanomechano-transduction (Osteo-4)
Dr. Paola Divieti Pajevic • Boston University

Kentucky Space/Exomedicine Lab – Flatworm
Dr. Mahendra Jain • Kentucky Space, LLC

Novartis Rodent Research-1
Dr. David Glass • Novartis Institute for Biomedical Research

Novartis Rodent Research-2
Dr. David Glass • Novartis Institute for Biomedical Research

Antibiotic Effectiveness in Space-1
Dr. David Klaus • University of Colorado Boulder

Molecular Biology of Plant Development (Petri Plants)
Dr. Anna-Lisa Paul • University of Florida

Effects of Simulated Microgravity on Cardiac Stem Cells
Dr. Joshua Hare • University of Miami

Protein Crystal Growth for Determination of Enzyme Mechanisms
Dr. Constance Schall • University of Toledo

PCG-Crystallization of Huntington Exon-1 Using Microgravity
Dr. Pamela Bjorkman • California Institute of Technology

T-Cell Activation in Aging-1 and -2
Dr. Millie Hughes-Fulford • Northern California Institute for Research and Education, Inc.

Impact of Increased Venous Pressure on Cerebral Blood Flow Velocity Morphology
Dr. Robert Hamilton • Neural Analytics

Drug Development and Human Biology: Use of Microgravity for Drug Development
Dr. Timothy Hammond • Veterans Administration Medical Center

PCG – Crystallization of Human Membrane Proteins in Microgravity
Dr. Stephen Aller • University of Alabama at Birmingham

PCG – IPPase Crystal Growth in Microgravity
Dr. Joseph Ng • iXpressGenes, Inc.

Merck PCG-1 and -2
Dr. Paul Reichert • Merck Pharmaceuticals

Exploiting On-Orbit Crystal Properties for Medical and Economic Targets
Dr. Edward Snell
Hauptman Woodward Medical Research Institute, Inc.

Collaborative Project– Protein Crystal Growth to Enable Therapeutic Discovery
Dr. Matt Clifton • Beryllium Discovery Corp.

Collaborative Project– Protein Crystal Growth to Enable Therapeutic Discovery
Dr. Cory Gerdts • Protein BioSolutions

PCG – Crystallization of Medically Relevant Proteins Using Microgravity
Dr. Sergey Korolev • Saint Louis University

COBRA PUMA GOLF Microgravity Electrodeposition
Mike Yagley • COBRA PUMA GOLF

Architecture to Transfer Remote Sensing Algorithms from Research to Operations
Dr. James Goodman • HySpeed Computing

Commercial Space-Borne Hyperspectral Harmful Algal Bloom (HAB) Products
Dr. Ruhul Amin • United States Naval Research Laboratory

Hyperspectral Mapping of Iron-bearing Minerals
Dr. William H. Farrand • Space Science Institute

Cyclone Intensity Measurements from the International Space Station (CIMISS)
Dr. Paul C. Joss • Visidyne, Inc.

Testing TiSi2 Nanonet Based Lithium Ion Batteries for Safety in Outer Space
Emily Fannon • EnerLeap

Utilize ISS Energy Systems Data for Microgrid Design and Operation
Nicholas Kurlas • Raja Systems

Reducing Signal Interruption From Cosmic-Ray Background in Neutron Detectors
Dr. Andrew Inglis • Silverside Detectors

Some projects in the ISS National Lab pipeline were originally selected and supported by NASA and other government agencies, such as the National Institutes of Health and the Department of Defense. These projects illustrate the importance of collaboration in supporting space-based research, something that CASIS continues to work toward in partnerships with other agencies and competitions. In particular, several ongoing projects currently in orbit (e.g., the alpha magnetic spectrometer, operated by an international team involving 16 countries and organized under the U.S. Department of Energy) are examples of successful long-term projects maintained by external management but supported by CASIS/ISS National Lab resources and allocation.

SPOT LIGHT

LEO Commercialization

The ISS National Lab can be a valuable platform for stimulating economic activity in low Earth orbit (LEO) for the benefit of life on Earth. Based on input from industry, academia, and government agencies, CASIS has identified three initial areas in which to enable utilization of the ISS for accelerating sustainable commercial activity in space.

Space-grown protein crystals

Protein Crystallization

LEO BENEFIT: Many crystals grown in microgravity are larger and more detailed than those grown on Earth, providing protein structures that are more accurate. This allows better structure-based drug designs while also informing improved strategies for drug manufacturing—with the end goal of more effective and affordable pharmaceuticals.

INDUSTRY INTEREST: This is the most developed of the three focus areas and has a substantial and growing demand in industry. CASIS is already working with Merck, Eli Lilly, and other pharmaceutical companies.

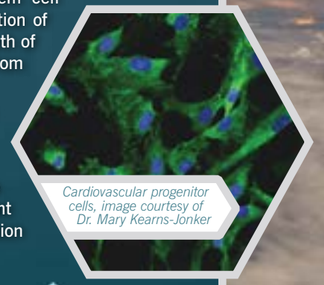
NEXT STEPS: Engage with the protein crystallization community, industry, and other government agencies to form small focus groups zeroed in on specific issues such as proteins of interest and hardware.

Organ and Tissue Bioengineering

LEO BENEFIT: Microgravity enhances the growth and survival of particular stem cell populations, promotes differentiation into specific cell types, and supports organization of individual cells into tissue-like structures. Organ and tissue bioengineering (e.g., growth of artificial organs for next-generation transplantation approaches) may directly benefit from near-term investment in space-based tissue-growth technologies and R&D.

INDUSTRY INTEREST: Early indications show some demand from small companies for microgravity-based R&D, and we expect rapid growth in demand as advances are made in R&D efforts.

NEXT STEPS: Leverage existing collaborations focused on this subject and determine how CASIS can best fit into existing consortia. Continue work with other government agencies to formulate a plan of public-private partnerships focused on open innovation and prize competitions to accelerate the pace of discovery and attract investment.



Cardiovascular progenitor cells, image courtesy of Dr. Mary Kearns-Jonker

In-Orbit Production

Made in Space 3-D printer

LEO BENEFIT: There are classes of materials with superior properties that can only be produced in the microgravity environment, thus demonstrating a need to utilize the ISS for future development in microgravity manufacturing of materials.

INDUSTRY INTEREST: In-orbit production is a broad area with early interest coming from wide-ranging industries, including additive manufacturing, semiconductor production, and exotic glass and fiber production, but it has not yet garnered widespread demand among large companies. This could dramatically change if proof-of-concept research is successful in-orbit.

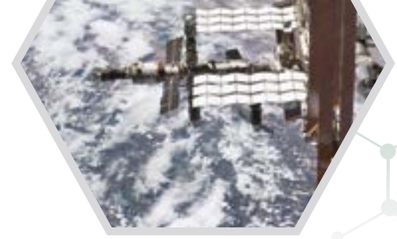
NEXT STEPS: Support proof-of-concept investigations and develop consortia to raise awareness among larger industrial participants in hopes of driving uptake and commercialization.

FINANCIALS

Statements of Financial Position as of September 30

Assets	2015	2014
Cash and cash equivalents	1,538,901	1,354,322
Grants receivable	392,845	—
Deposits	2,440	3,281
Prepaid expenses	185,945	340,058
Intangibles, net of accumulated amortization of $28,166 and $20,759, respectively	3,280	10,687
Property and equipment at cost, net of accumulated depreciation of $507,713 and $340,990, respectively	159,856	174,061
Total assets	**$2,283,267**	**$1,882,409**

Liabilities and net assets	2015	2014
LIABILITIES		
Accounts payable and accrued expenses	342,102	238,293
Deferred grant revenue	—	252,765
Total liabilities	**$342,102**	**$491,058**
NET ASSETS		
Unrestricted net assets	197,247	206,433
Temporarily restricted net assets	1,743,918	1,184,918
Total net assets	**$1,941,165**	**$1,391,351**
Total liabilities and net assets	**$2,283,267**	**$1,882,409**



Statements of Activities for the years ended September 30

Revenues and other support	2015	2014
Federal grants	14,836,610	15,273,635
Contributions	807,430	9,193
Memberships*	—	35
Donated facility	111,195	75,750
Interest income	5,351	2,525
Total revenues and other support	**$15,760,586**	**$15,361,138**

Expenses	2015	2014
Program services	13,667,875	12,453,484
Supporting services	1,542,897	2,996,181
Total operating expenses	**$15,210,772**	**$15,449,665**
Change in net assets	549,814	(88,527)
Net assets, beginning of the year	1,391,351	1,479,878
Net assets, end of the year	**$1,941,165**	**$1,391,351**

Summarized financial statements from CASIS fiscal year 2015. Audited financial statements, including footnotes as an integral part of the statements, are available upon request. Audit reports issued by Carr, Riggs & Ingram, LLC, November 2015.

* The paid membership model was discontinued at the beginning of FY14.

ANNUAL REPORT FY2015

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